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APOLLO MISSION E: AS-504/CSM-104/LM-4 SPACECRAFT PRELIMINARY ALTERNATE MISSION STUDIES

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PROJECT APOLLO

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1. INTRODUCTION AND SUMMARY

1.1 PURPOSE

This document presents the current alternate mission strategy for the E mission, so that an evaluation can be made of the impact of these missions on operations, crew activities, and systems usage. In addition to the seven alternate missions, this document includes the functional failures used to generate the alternates and the technical approach to design them. Constructive criticism and suggestions, especially concerning the need for additional alternates or problems in the existing set, will be integrated into the final alternate mission plan document. This preliminary plan will provide flight control with a comprehensive but finite set of alternate missions to integrate into the mission rules. This plan also provides flight crew personnel with information to evaluate the effect on flight plans, crew procedures, and training plans. The modified rendezvous plans will be established and published after the nominal rendezvous plan becomes more definitive.

1.2 TECHNICAL APPROACH

The alternate missions that are presented have been carefully constructed so that individual segments may be used as building blocks in real time to construct a new profile based on current system status. To implement this philosophy, most alternates return to the nominal mission sequence of events, and all alternate missions have various points of entry. The modified rendezvous plans that will be presented later may be incorporated into one of the alternate missions in real time.

Since the alternate missions in this document were developed before the mission rules were established, reasonable functional failures were postulated and their effect upon the remaining system capability was examined. After finding functional failures that required an alternate mission, a timeline was developed to meet as many detailed test objectives (as presented in the Appendix) as possible. The alternate mission timelines account for the limited capabilities of the vehicle and the relative priorities of the test objectives. As the mission rules evolve, they will generally incorporate the alternate missions identified through this functional failure analysis.

1.3 SCOPE

Section 2 lists the nomenclature used in this report. Section 3 presents a brief nominal mission description based on the reference trajectory (RT) (Reference 1). This document is based on the same input as the RT. Spacecraft weight and propulsion characteristics, Manned Space Flight Network (MSFN) stations, crew activity timeline assumptions, and consumable rate utilization assumptions are referenced or summarized in Section 4. Definitions, ground rules, and mission timeline assumptions are provided in Section 5.

The functional failures which lead to the various alternates are identified in Section 6, along with an alternate mission matrix based on these functional failures. In the operational alternate mission plan, this list of functional failures will be expanded. Section 7 discusses each alternate mission plan including a general description, operational limitations, a typical reason for calling it, and effects on mandatory test objectives. Specific data for each alternate include mission timelines, summaries of major mission events, engine burn summaries, and relevant data from special studies.

Section 8 describes the modified rendezvous plans. These plans are not included in this preliminary document because the nominal mission rendezvous profile has not been finalized. These plans will be included in the final alternate mission plan document, and at least one sequence will be feasible for each alternate mission that calls for a modified rendezvous. Section 9 presents a matrix that indicates the extent to which each alternate satisfies the detailed test objectives. The detailed test objectives and priorities from Reference 2 are summarized in the Appendix.

Launch aborts, ~~and~~ command service module (CSM) rescue, and aborted rendezvous will be covered in separate publications.

1.4 PROBLEM AREAS

It was found that nonnominal operating procedures and irregular situations arose from certain functional failures and the alternate missions designed to cope with these failures. It is of particular importance that the parties of interest return any comments of relevance pertaining to

these procedures so that the final alternate mission plan can be as complete as possible. The following is a synopsis of the pertinent problems:

a) In many of the alternates it was necessary to execute the MCC and LOI burns in less than one hour with only one IMU alignment. Since the MCC burn is inplane and the LOI burn is almost completely out-of-plane, it is proposed to align the inertial measurement unit (IMU) 45 degrees out-of-plane to avoid the gimbal lock problem and still allow both burns with only the one alignment. However, it is not known how accurately the crew will be able to monitor the burn attitudes with the eight-ball. In addition, it is not known if control dispersions during the burns for this situation will be acceptable.

b) With a premature S-IVB TLI cutoff (functional failure 5), the possibility exists of inserting into an orbit with a radiation hazard to the crew. Therefore, it is desirable to lower apogee at the earliest possible time, which occurs at the first perigee pass.

The orbit that results from the premature TLI shutdown will have a 100-nautical mile perigee altitude and the apogee altitude will be a function of the TLI burn duration. Currently Alternate Mission C calls for the MCC burn at the first apogee to raise perigee altitude to 130 nautical miles. The LOI burn is then utilized at the first perigee to lower the apogee altitude to 400 nautical miles and alleviate the radiation hazard.

The problem specified in (a) above exists in alternate C also. To be conservative, it was originally proposed to delete the MCC burn and align the IMU for the large LOI burn. However, the perigee altitude at which the LOI burn would then take place is 100 nautical miles and it is possible that LOI burn attitude dispersions could result in extremely low perigee altitudes that would jeopardize the mission. Therefore, it is desirable to obtain the anticipated LOI burn dispersion studies so that a minimum perigee altitude may be defined for the LOI burn simulation.

c) The targeting for the long DPS burn simulation of the main powered descent maneuver must consider attitude and attitude rate sensitivities. The final alternate mission targeting will therefore be determined considering sensitivity studies now being conducted.

2. ABBREVIATIONS

ACN	Ascension Tracking Station
AGS	abort guidance system
ANT	Antigua Tracking Station
APS	ascent propulsion system
BDA	Bermuda Tracking Station
CDH	constant differential height maneuver
CDR	commander
CFP	concentric flight plan
CM	command module
CNB	Canberra Tracking Station
CNM	continue nominal mission
COI	contingency orbit insertion
CRO	Carnarvon Tracking Station
CSI	coelliptic sequence initiation
CSM	command service module
CYI	Canary Islands Tracking Station
DAP	digital autopilot
DOI	descent orbit insertion
DPS	descent propulsion system
DTO	detailed test objective
ECS	environmental control system
EPS	electrical power system
ETR	eastern test range
GBM	Grand Bahama Island Tracking Station
GDS	Goldstone Tracking Station

g. e. t.	ground elapsed time, from lift-off
GMT	Greenwich Mean Time
GNCS	CSM guidance and navigation control system
GWM	Guam Tracking Station
HAW	Hawaii Tracking Station
HTV	Huntsville Tracking Station
IMU	inertial measurement unit
IVT	intra-vehicular transfer
LAPG	Lambert aim-point guidance
LOI	lunar orbit insertion
LM	lunar module
LMP	lunar module pilot
MAD	Madrid Tracking Station
MCC	midcourse correction
MER	Mercury Tracking Ship
MIL	Merritt Island Tracking Station
MPAD	Mission Planning and Analysis Division
MPD	main powered descent
MSFN	Manned Space Flight Network
MTVC	manual thrust vector control
PGNCS	LM primary guidance and navigation control system
PRE	Pretoria Tracking Station
RCS	reaction control system
RED	Redstone Tracking Ship
RT	reference trajectory
RTACF	Real Time Auxiliary Computing Facility
RTCC	Real-Time Computer Complex

SC	spacecraft
S-II	second stage of Saturn V configuration
S-IVB	third stage of Saturn V configuration
SLA	spacecraft LM adapter
SM	service module
SPS	service propulsion system
S-V	Saturn V launch vehicle
TAN	Tananarive Tracking Station
T, D, AND E	transposition, docking, and ejection
TEI	transearth injection
TEX	Texas Tracking Station
TLI	translunar injection
TOI	transfer orbit insertion
TPF	terminal phase finalization
TPI	terminal phase initiation
TVC	thrust vector control
US	United States
VAN	Vanguard Tracking Ship
WHS	White Sands Tracking Station
WTN	Watertown Tracking Ship
h_a	apogee altitude
h_p	perigee altitude
ΔV	delta velocity

Nominal mission description

3. NOMINAL MISSION DESCRIPTION

Apollo Mission E (AS-504/CSM-104/LM-4) is a combined CSM and lunar module (LM) mission designed to demonstrate the normal modes of spacecraft operations on a simulated lunar mission timeline. A summary of major mission events organized by period of activities is presented in Table 3-1. A detailed Mission E events summary is shown in Table 3-2. The service propulsion system (SPS), the descent propulsion system (DPS), and the ascent propulsion system (APS) burn summaries are presented in Table 3-3. A detailed description of the nominal E mission can be found in Reference 1.

The first period of activity begins with the AS-504 launch from complex 39A. For simulation purposes, liftoff is assumed to occur on 1 December 1968 at 1900 hours Greenwich Mean Time (GMT) on a flight azimuth of 72 degrees from true north. The launch phase is completed with insertion into a 100-nautical mile circular parking orbit. The S-IVB translunar injection (TLI) simulation maneuver which places the docked S-IVB/CSM/LM combination into a high apogee orbit is followed by the transposition, docking, and LM ejection maneuver. During the high apogee phase of the mission, a midcourse correction maneuver and deep space navigation exercises are accomplished. The high apogee is reduced with the lunar orbit insertion (LOI) simulation maneuver. The first period of activities is completed with the SPS burn which circularizes the orbit at a 150-nautical mile altitude. The second period of activities consists of the docked descent orbit insertion (DOI) and the main powered descent (MPD) simulation. The LM-active rendezvous is performed in period three, and the CSM-active rendezvous is performed in period four. In the fifth period, the orbit is shaped to enhance CSM deorbit capability with the transearth injection (TEI) simulation maneuver and a reaction control system (RCS) midcourse correction simulation. The remainder of the fifth period is devoted to CSM solo activities. Deorbit and reentry will occur approximately 9 days and 22 hours following liftoff.

Table 3-1. Nominal Mission E Summary of Mission Events

Period 1	Period 2	Period 3	Period 4	Period 5
• Launch	• Docked DOI Simulation	• LM-active Rendezvous	• CSM-active Rendezvous	• TEI Simulation Maneuver
• Insertion into Earth Parking Orbit	• Docked MPD Simulation			• RCS MCC Maneuver
• TLI Simulation Maneuver	• SPS Trim Maneuver			• Deorbit
• T, D, and E				• Touchdown
• MCC Maneuver				
• Deep Space Navigation Exercises				
• LOI Simulation Maneuver				
• Circularization Maneuver				

Table 3-2. Nominal Mission E Detailed Spacecraft Events Summary

Event	Ground Elapsed Time at Initiation (day:hr:min:sec)	Duration (hr:min:sec)	Position at Initiation			Resulting h_a/h_p (n mi)	ΔV (fps)	Station Coverage
			Geodetic Latitude (deg)	Longitude (deg)	Altitude (n mi)			
(a) First Period of Activities								
Launch	00:00:00:00	00:11:25	28.5	-80.1	0	--	--	MIL, GBN, BDA VAN
Insertion	00:00:11:35	--	32.0	-54.0	104	104/100	--	VAN
Injection (TLI)	00:03:16:52	00:02:33	26.0	-62.0	104	3956/107	4220	BDA, VAN
T, D, and E	00:03:43:40	00:47:35	-21.5	23.4	1529	--	--	ACN, CRO, CNB, GWM
MCC Maneuver	00:07:31:34	00:00:05	-25.4	60.3	3956	3956/130	34	RED, CRO
Third Apogee Navigational Sightings	00:09:44:58	01:12:55	-32.5	-22.7	3000	--	--	ACN, RED
Fourth Apogee Navigational Sightings	00:12:34:52	01:12:56	-32.5	-65.1	3000	--	--	HTV, ANT
LOI Maneuver	00:14:32:21	00:07:44	30.5	115.3	181	400/130	3724	MER, GWM
Circularization Maneuver	01:06:12:23	00:00:59	32.2	-132.5	152	150/150	595	CAL
(b) Second Period of Activities								
Docked DPS DOI Maneuver	01:22:41:40	00:01:09	31.7	-22.2	150	150/150	40	CYI
Docked DPS MPD Maneuver	01:23:53:00	00:10:41	17.3	-122.2	149	164/149	2848	WTN, GYM, TEX, MIL, GBN
SPS Trim Burn	02:04:40:07	00:00:02	28.1	-122.4	150	150/150	37	CAL
(c) Third Period of Activities								
CSM/LM Separation	02:22:22:20	00:00:01	21.0	-104.1	149	--	1	TEX
DPS Phasing Maneuver	02:22:40:45	00:00:31	25.6	-27.4	149	159/136	79	CYI
DPS CDH Maneuver	03:01:22:37	00:00:12	22.2	-146.8	159	159/159	41	HAW
APS CSI Maneuver	03:03:34:40	00:00:03	-17.3	-13.1	158	158/140	33	ACN
APS CDH Maneuver	03:04:20:19	00:00:03	18.5	158.0	139	139/139	33	GWM
TPI	03:05:02:17	00:00:18	-13.8	-43.1	139	151/138	22	None
First Braking Gate	03:05:31:17	00:00:11	-16.6	73.0	147	151/146	14	None
Second Braking Gate	03:05:36:54	00:00:08	-6.2	92.0	148	150/148	9	None
Docking	03:05:50:00	00:10:00	23.1	143.0	149	149/149	--	MER, GWM

Table 3-2. Nominal Mission E Detailed Spacecraft Events Summary (Concluded)

Event	Ground Elapsed Time at Initiation (day:hr:min:sec)	Duration (hr:min:sec)	Position at Initiation			Resulting h_a/h_p (n mi)	ΔV (fps)	Station Coverage
			Geodetic Latitude (deg)	Longitude (deg)	Altitude (n mi)			
			(d) Fourth Period of Activities					
CSM/LM Separation	03:23:56:40	00:00:02	28.9	-104.8	149	149/149	1	TEX
SPS Phasing Maneuver	04:01:16:58	00:00:04	17.8	-165.2	148	156/129	86	HAW
SPS Concentric Maneuver	04:02:27:59	00:00:02	17.3	110.0	156	156/156	48	CRO
TPI	04:03:36:24	00:00:40	-24.7	-1.6	156	156/146	17	None
First Braking Gate	04:04:04:18	00:00:14	-5.6	108.1	148	153/147	6	None
Second Braking Gate	04:04:09:52	00:00:22	5.4	126.1	147	150/147	9	None
RCS Separation Maneuver	04:04:22:57	00:00:05	26.5	173.4	149	152/149	2	None
			(e) Fifth Period of Activities					
Transearth Injection Burn	06:00:32:00	00:00:30	-25.3	30.7	150	200/90	700	RED
RCS MCC Maneuver	07:22:13:20	00:00:21	29.2	-100.9	135	194/89	10	TEX
Deorbit	09:21:45:54	00:00:12	19.5	-159.2	183	191/-54	294	HAW
Touchdown								

Table 3-3. Nominal Mission E Burn Summaries

a. SPS Burn Summary

Burn Number	Event	Ground Elapsed Time at Initiation (day:hr:min:sec)	Duration (sec)	ΔV (fps)	Control Mode	Configuration	MSFN Coverage (5 deg)	Resulting h_a/h_p (n mi)
1	MCC Maneuver	00:07:31:34	5.1	34	GNCS/ LAPG	Docked	RED CRO	3956/130
2	LOI Maneuver	00:14:32:21	463.6	3724	GNCS/ LAPG	Docked	MER GWM	400/130
3	Circularization	01:06:12:23	59.0	595	GNCS/ MTVC/ EXT ΔV	Docked	CAL	150/150
4	Trim Maneuver	02:04:40:07	1.8	37	GNCS/ EXT ΔV	Docked	CAL	150/150
5	Phasing Maneuver	04:01:16:58	3.6	86	GNCS/ EXT ΔV	CSM Solo	HAW	156/129
6	Concentric Maneuver	04:02:27:59	1.8	48	GNCS/ EXT ΔV	CSM Solo	CRO	156/156
7	TEI Maneuver	06:00:32:00	30.0	700	GNCS/ LAPG	CSM Solo	RED	200/90
8	Deorbit	09:21:45:54	12.0	294	GNCS/ EXT ΔV	CSM Solo	HAW	191/-54

Table 3-3. Nominal Mission E Burn Summaries (Concluded)

b. DPS Burn Summary

Burn Number	Event	Ground Elapsed Time at Initiation (day:hr:min:sec)	Duration (sec)	ΔV (fps)	Control Mode	Configuration	MSFN Coverage (5 deg)	Resulting h_a/h_p (n mi)
1	DOI Maneuver	01:22:41:40	69.0	40	PGNCS/ EXT ΔV	Docked	CYI	150/150
2	MPD Maneuver	01:23:53:00	640.0	2848	PGNCS/ EXT ΔV	Docked	WTN, GYM, TEX, MIL, GBI	164/149
3	Phasing Maneuver	02:22:40:45	31.0	79	AGS/ EXT ΔV	LM Solo	CYI	159/156
4	CDH Maneuver	03:01:22:37	12.0	41	AGS/ EXT ΔV	LM Solo	HAW	159/159

c. APS Burn Summary

Burn Number	Event	Ground Elapsed Time at Initiation (day:hr:min:sec)	Duration (sec)	ΔV (fps)	Control Mode	Configuration	MSFN Coverage (5 deg)	Resulting h_a/h_p (n mi)
1	CSI Maneuver	03:03:34:40	2.7	33	PGNCS/ EXT ΔV	LM Solo	ACN	158/140
2	CDH Maneuver	03:04:20:19	2.7	33	PGNCS/ EXT ΔV	LM Solo	GWM	139/139

Summary of input data

4. SUMMARY OF INPUT DATA

Input data used in the preparation of this document were obtained from the following sources:

Mission E Detailed Test Objectives (Appendix)	Reference 2
Mission Constraints	References 3, 4, and 5
Spacecraft Parameters, Performance, and Aerodynamic Coefficients	References 3 and 4
Tracking Equipment and the Location of the Ground Stations	Reference 6
LM Consumables (Table 4-1)	Reference 7

The LM consumables data, which were assumed for the preliminary E alternate mission work, are summarized in Table 4-1 and were derived from Reference 7. CSM consumables data are in general not as critical as the LM data, with regard to alternate mission planning, and consequently, are not presented.

Table 4-1. LM Consumables Data*

Stage	Activity	Rate of Electrical Energy Expenditure (% of electrical energy/hr)	Rate of Cabin Oxygen Usage** (% of oxygen/hr)
Descent	Docked Coast	3.9	0.78
Descent	Docked DPS Burn	3.2	0.78
Descent	H_2O Boiler Dryout	3.5	0.78
Descent	Rendezvous Phase	4.0	0.78
Ascent	Pre-LM Jettison Operations	5.2	8.47
Ascent	Post-LM Jettison Target Vehicle in PGNCS	5.8	8.47
Ascent	H_2O Boiler Dryout	8.7	8.47
Ascent	Rendezvous Phase	12.0	8.47
Ascent	Docking Phase	10.2	8.47

*These data are approximate and are intended for planning purposes only. They were obtained from Reference 7.

**The rate of oxygen usage is constant, independent of the activity.

Definitions, ground rules, assumptions

5. DEFINITIONS, GROUND RULES, AND MISSION TIMELINE ASSUMPTIONS

5.1 DEFINITIONS

Several terms which are used in this report are defined below.

Alternate mission	Any deviation from the nominal mission timeline where further mission objectives are considered before the end of the mission
Abort	Any situation where crew safety requires immediate mission termination; no further mission objectives are considered
Modified rendezvous	Any rendezvous planned and deliberately executed in lieu of the nominal rendezvous plan in order to achieve mission objectives
Aborted rendezvous	Any nonnominal rendezvous plan precipitated by an unexpected anomaly occurring during the actual nominal rendezvous sequence and executed solely to achieve rendezvous

5.2 GROUND RULES

The following ground rules were derived from the E mission requirements document (Reference 2):

a) LM test objectives take first priority.

b) If possible, alternate mission timelines will return to the nominal timeline.

c) Multiple failures will not, in general, be considered.

d) The S-IVB will not be considered after spacecraft (SC) separation.

e) Negligible additional crew training will be required for alternates.

f) No additional Real-Time Computing Complex (RTCC) processors will be necessary; unusual real-time processing requirements will be incorporated into the Real-Time Auxiliary Computing Facility (RTACF).

g) Alternate mission planning will be consistent with current spacecraft, crew, and operational constraints.

h) Each alternate mission will contain a scheduled deorbit.

i) Aborted alternate missions will not be considered.

j) SPS failure requires a mission abort.

5.3 MISSION TIMELINE ASSUMPTIONS

The assumptions listed below were coordinated through the Flight Crew Support Division and utilized in the design of the alternate mission timelines for the E mission. In some instances these assumptions were the result of attempting to shorten the alternate mission while still satisfying the mandatory detailed test objectives.

a) Forty-five minutes were allowed for transposition docking, and LM ejection.

b) In most cases, twenty minutes were allowed for IMU alignment.

c) A seven- to eight-hour sleep period, with all astronauts sleeping simultaneously, and a one hour eat period were used throughout.

d) Ten to fifteen minutes were allowed for LMP and CDR intravehicular transfer.

e) Undocking was not attempted with a LM primary coolant loop failure.

Alternate plans and failure analysis

6. THE ALTERNATE MISSION PLANS AND FUNCTIONAL FAILURE ANALYSIS

The alternate mission plans and the functional failure analysis that established their requirements are outlined in Section 6.1 and 6.2, respectively. The alternate mission notation is described in Section 6.3, and the concept of the alternate mission matrix is introduced in Section 6.4.

6.1 SUMMARY OF ALTERNATE MISSION PLANS

A brief outline of the seven alternate missions is provided in Table 6-1. The period of entry into the alternate mission sequence is shown on the left-hand side of the page. After the alternate mission of interest and the period of entry have been established, the major events and the deviations from the nominal mission can be determined by reading across from the period of entry and then down the sequence.

The following types of functional failures generated the requirements for these alternate mission plans: premature S-IVB cutoff, inability to eject the LM from the spacecraft LM adaptor (SLA), CSM systems lifetime problem, DPS failures, LM environmental control system (ECS) primary coolant loop failure, spacecraft electrical power failures, and LM primary guidance and navigation control system (PGNCS) or abort guidance system (AGS) failure. Other CSM systems failures, i.e., SPS failures, were considered but judged to require mission aborts as opposed to alternate missions.

Several alternate missions were considered but rejected for various reasons. Among these alternates were the following:

- Inserting only the CSM into a high apogee ellipse, following contingency orbit insertion (COI), in order to accomplish the high altitude detailed test objectives. An altitude equivalent to the nominal apogee altitude is required in order to meet the objectives of the navigation sightings experiments. A performance analysis showed that a high speed reentry from the high altitude ellipse would be required since insufficient propellants remain to lower the apogee of the high ellipse orbit after initially raising the apogee to the nominal altitude. This alternate was rejected because the high speed reentry was considered to be undesirable from a crew safety point of view.

- Raising apogee to the nominal altitude with the SPS following a premature S-IVB TLI shutdown. Performance analysis showed that the nominal apogee altitude could be obtained only after achieving a predicted apogee altitude equivalent to approximately 3700 nautical miles following a premature S-IVB cutoff, and still accomplish the remainder of the mission activities. In addition, the nonnominal period of the first high apogee orbit severely compromised the MSFN coverage for the LOI burn simulation and the lighting for the navigation sighting experiments. This alternate was rejected for these reasons.

- Raising apogee with the SPS (LOI simulation) and lowering apogee with the DPS (MPD simulation) following S-IVB TLI ignition failure. This alternate mission was rejected because of high radiation exposure to the LM astronaut while manning the LM for the required set up, prior to the MPD burn.

- An alternate mission to accommodate all Mission E mandatory DTO's in the shortest possible time. This type of alternate is precipitated by a CSM systems failure which reduces the nominal lifetime of that system. Extensive effort was spent to design such an alternate. To accomplish this, the LMP is required to work continuously for approximately 26 hours and the MSFN coverage for the LM-active rendezvous is sparse. In addition, the time saved, compared to the nominal mission timeline, amounted to approximately 24 hours. Therefore, in light of the above mission compromises, if all E mission mandatory DTO's are to be attempted, it is recommended that the nominal mission timeline be followed as long as possible rather than design a specific alternate mission.

6.2 FUNCTIONAL FAILURE ANALYSIS

An outline of the functional failure analysis that generated the requirements for this set of alternate missions is provided in Table 6-2.

6.3 ALTERNATE MISSION NOTATION

The seven general alternate missions (A through G) are basic sequences of events which may be entered during various periods of activity. A building block arrangement is utilized to construct each unique alternate mission timeline. To handle the variety of circumstances, the following notation is used in the designation of specific alternate missions:

- Upper Case Letter — Refers to the general alternate mission sequence of events

• Number	Refers to the nominal mission period of activities in which the alternate mission sequence of events is entered
• Lower Case Letter	Identifies a unique mission timeline (g. e. t. of event initiation is specified) associated with the general alternate mission

For example, E-2a is a unique alternate mission, entering the general alternate mission E sequence of events in period two and having a unique mission timeline ("a"). Alternate mission E-2b enters the same sequence of events (E) in the same period (period 2), but contrasts from E-2a in that the g. e. t. at initiation of the events differ. Alternate missions E-2a and E-3a use the same sequence of events (E) and unique mission time ("a") and differ only in that E-3a enters the mission timeline "a" in period 3.

Since the "a" mission timelines represent the basic logic involved in constructing the alternate missions, additional timelines ("b"s, "c"s, etc.) are omitted in this preliminary document.

6.4 MISSION RULES AND THE ALTERNATE MISSION MATRIX

The operational alternate mission plan will present an alternate mission matrix which will list, according to system and mission period, the mission rules which call for an alternate mission. The mission rule designations used in this matrix will correspond to those used in the E mission rule document. Because it is desirable to demonstrate the utility and the format of this matrix in this preliminary report, even though the mission rules are not available, functional failures occurring in the top of the matrix in Table 6-3 have been substituted for mission rules. The same mission rule or functional failure may require different alternates, depending on when the contingency occurs. Also, the same basic alternate may be entered from different periods or called by different mission rules. To handle this variety of circumstances, the alternate mission notation that is defined in Section 6. 3 is used in Table 6-3.

The alternate mission matrix can become a valuable tool for use during real time spaceflight operations. For example, if one of the

functional failures listed across the top of the matrix occurs, it will be discovered or recognized during some event or activity of the nominal mission sequence of events. This sequence is outlined down the left-hand column of the matrix. The entry in the matrix for the time in the mission corresponding to the discovery of the particular failure specifies the action to be taken. The alternate missions specified in the matrix are described in detail in Section 7. Note that though a failure may eventually culminate in an alternate, it need not do so in the same activity period in which it was recognized.

Table 6-1. Alternate Mission Descriptions

Period of Entry		
		Alternate A
1	•	CSM only mission (accomplish CSM test objectives)
		Alternate B
1	•	Continue in insertion orbit
	•	Perform transposition, docking, and LM ejection
	•	Perform SPS MCC burn to provide 130- by 100-nautical mile ellipse
	•	Perform LOI burn partially out-of-plane
	•	Continue nominal mission activities
		Alternate C
1	•	S-IVB restart (25-second burn)
	•	Perform transposition, docking, and LM ejection on first apogee pass
	•	Perform SPS burn to lower apogee to an acceptable altitude consistent with radiation and mission constraints
	•	Continue nominal mission activities
		Alternate D
1	•	Perform transposition, docking, and LM ejection
	•	SPS MCC burn to provide 130- by 100- nautical mile ellipse
	•	Perform LOI burn partially out of plane
	•	SPS burn to circularize orbit at 150 nautical miles
2	•	Docked DPS burns
	•	SPS trim burn
3	•	LM active rendezvous
	•	Deorbit

Table 6-1. Alternate Mission Descriptions (Concluded)

Period of Entry		Alternate E
2	•	Delete docked DPS burns
	•	Delete LM active rendezvous
	•	Continue nominal mission activities
		Alternate F
2	•	Delete docked DPS burn
3	•	Execute modified rendezvous
	•	Continue nominal mission activities
		Alternate G
3	•	Execute modified rendezvous
	•	Continue nominal mission activities

Table 6-2. Functional Failure Analysis

Failure Number	Functional Failure	Action	Notes
1	COI	Alternate A	Establish CSM only detailed test objectives.
2	LM cannot be ejected from SLA	Alternate A	
3	No S-IVB restart	Alternate B	
4	S-II under performance	Alternate C	Alternate C is required here only if S-IVB propellents are not sufficient to achieve an apogee greater than 2700 nautical miles.
5	Premature S-IVB TLI cutoff		
	a) $h_a \geq 2700$ n mi	Continue mission.	
	b) $h_a \leq 2700$ n mi	Alternate C	LOI simulation may not be covered. Astronaut is in tunnel following docking and may be exposed to high radiation dosage.
6	CSM systems lifetime problem	Alternate D	
7	DPS fails to ignite		
	a) for DOI	Continue mission.	
	b) for MPD	Continue Mission.	

Table 6-2. Functional Failure Analysis (Continued)

Failure Number	Functional Failure	Action	Notes
8	LM primary coolant loop failure		
	a) before separation maneuver	Alternate E	The emergency coolant loop does not cool the PGNCS.
	b) after separation maneuver	Terminate rendezvous at first opportunity and continue mission or CSM rescue and continue mission.	
9	LM PGNCS lost		
	a) before completion of MPD burn	Alternate F	
	b) before CSM-LM separation	Alternate G	Docked DPS burns cannot be performed on AGS.
	c) after CSM-LM separation	Switch to AGS and terminate rendezvous at first opportunity.	
10	LM AGS lost		
	a) before separation maneuver	Continue mission.	

Table 6-2. Functional Failure Analysis (Continued)

Failure Number	Functional Failure	Action	Notes
	b) after separation maneuver	Continue mission.	Use PGNCS in place of AGS where appropriate.
11	Rendezvous Radar failure		
	a) before separation maneuver	Alternate G (station keeping)	Would the nominal rendezvous be considered if the terminal phase maneuvers were executed over tracking stations?
	b) between separation maneuver and phasing maneuver	Terminate rendezvous at first opportunity.	Stage LM prior to CSM capture
	c) after phasing maneuver	Continue mission.	
12	Descent stage electrical power failure		
	a) before separation maneuver	Alternate G	
	b) after separation maneuver	Terminate rendezvous at first opportunity and continue mission or continue mission.	

Table 6-2. Functional Failure Analysis (Concluded)

Failure Number	Functional Failure	Action	Notes
13	One ascent battery fails		
	a) before separation maneuver	Alternate G	
	b) separation maneuver to phasing maneuver	Terminate rendezvous at first opportunity and continue mission.	
	c) after phasing maneuver	Continue mission or CSM rescue.	

Alternate mission matrix

Table 6-3. The Alternate Mission Matrix

Period	Event	COI	LM Cannot Be Ejected from SLA	S-IVB Fails To Restart	S-II Under Performance	Premature S-IVB TLI Cutoff $h_{a1} \leq 2700$	CSM System Lifetime Problem	DPS Fails To Ignite	LM Primary Coolant Loop Failure	LM PGNCS Lost	LM AGS Lost	Rendezvous Radar Failure	Descent Stage Electric Power Failure	One Ascent Battery Fails
		Functional Failures												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Insertion	A-1a			C-1a*		D-1a/CNM**							
	Injection (TLI)			B-1a		C-1a	D-1a/CNM**							
	T&D						CNM**							
	LM Ejection		A-1b				CNM**							
	MCC Maneuver						CNM**							
	Third Apogee Navigation Sightings						CNM**							
	Fourth Apogee Navigation Sightings						CNM**							
	LOI Maneuver						CNM**							
	Circularization Maneuver						CNM**							
2	Docked DPS DOI Maneuver						CNM**	CNM***	E-2a	F-2a	CNM	G-3x	CNM/G-3	G-3x
	Ignition of Docked DPS MPD Maneuver						CNM**	CNM***	E-2a	F-2a				
	Completion of Docked DPS MPD Maneuver						CNM**	CNM***	E-3b	G-3x	CNM	G-3x		
	SPS Trim Burn						CNM**		E-3b	G-3x	CNM	G-3x		
3	IVT								E-3b	G-3x	CNM	G-3x		
	CSM/LM Separation								E-3b	G-3x	CNM	G-3x		
	Phasing Maneuver									G-3x	CNM			
	TPI										CNM			
	Docking													
4	CSM/LM Separation													
	SPS Phasing Maneuver													
	SPS Concentric Maneuver													
	TPI													
	RCS Separation Maneuver													
5	TEI Burn													
	RCS MCC Maneuver													
	Deorbit													

NOTE: Alternate missions have not been designed for failures occurring after the completion of the LM-active rendezvous.

*Continuous range of timelines will require real-time construction of specific timeline.

**Follow nominal timeline and deorbit after LM-active rendezvous.

***Continue nominal mission but lighting and coverage the same as F-2a timeline.

x Modified rendezvous timelines will be provided at a later date.

7. DETAILED ALTERNATE MISSION DESCRIPTIONS

The seven general alternate missions (A through G) and specific applications of each are presented herein. A justification of the need for each alternate, a general description of the alternates, and an indication of mandatory detailed test objective (DTO) accomplishments of each alternate are included. A detailed period by period description of specific examples (mission timelines) of each of the alternate missions is presented.

Alternate Mission A

7.1 ALTERNATE MISSION A

Alternate Mission A is a "CSM only" mission. This alternate is required to accommodate functional failure 1 (premature S-IVB cutoff resulting in a contingency orbit insertion) and functional failure 2 (LM cannot be ejected from SLA). For functional failure 1 the alternate mission may be similiar to the CSM alone mission outlined for the "D" mission. For functional failure 2 the CSM is on the high apogee orbit, and the alternate mission will allow for the completion of the high altitude communication and navigation experiments.

Alternate Mission B

7.2 ALTERNATE MISSION B

This alternate mission is precipitated by a failure of the S-IVB to restart for the simulated TLI burn (functional failure 3). Due to this failure, the following Mission E mandatory DTO's are lost: M20.57 (CSM/MSFN High Altitude Communications), M20.58 (Star/Landmark Navigation), and M20.59 (Star/Earth Horizon Navigation). The example for this alternate mission which is discussed below was an attempt to move the LOI burn and the subsequent nominal mission activities forward in time to avoid leaving the block of time nominally devoted to the high altitude activities devoid of activity. A spacecraft events summary and mission timeline, including tracking and lighting coverage, are presented in Table 7-1 and Figure 7-1, respectively. Table 7-2 presents an engine burn summary for this alternate.

Period 1

Alternate B is initiated during the first period of activities following a failure of the S-IVB to restart. Following the failure, the CSM separates from the S-IVB/LM and completes transposition and docking. Upon completion of hard docking, the CSM/LM are ejected from the SLA. The inertial measurement unit (IMU) is aligned 45 degrees out-of-plane at approximately 6:20:00 g.e.t., in preparation for the first two SPS burns in this period of activities. The first SPS burn is an inplane, simulated midcourse correction (MCC) burn which results in altering the circular orbit to a 130- by 100-nautical mile ellipse. The second SPS burn is a simulation of the LOI. The LOI burn is performed at apogee and is targeted to yield a new apogee of 400 nautical miles. The remainder of the LOI burn is applied out-of-plane. Since coverage is not available for the entire burn, the initiation of the burn is timed such that termination occurred over a tracking station. Following the LOI burn, the IMU is realigned in preparation for the third SPS burn. This burn is performed just prior to perigee and results in circularizing the orbit at an altitude of 150 nautical miles.

Period 2

Following an eat-sleep-eat cycle, the crew prepares for and performs the two docked DPS burns and the LM-active rendezvous. The

LM-active rendezvous is nominally performed in the third period of activities; however, since the high ellipse portion of the mission was deleted, the need for separate crew sleep and eat periods was eliminated and simultaneous sleep could be performed. Therefore, the remaining nominal mission activities are brought forward in time. This period of activities culminates in the completion of the LM-active rendezvous with CSM/LM hard docking and the transfer of the commander (CDR) and lunar module pilot (LMP) back to the CSM.

Period 3

The activities during this period are devoted to the performance of the CSM-active rendezvous with an unmanned LM ascent stage. The rendezvous is designed to simulate a typical lunar CSM rescue from above and ahead.

The remainder of the mission from the end of period three through reentry will be to perform the nominal mission activities; however, these activities will be performed following the alternate mission timeline presented in Figure 7-1.

If it is determined that the LOI coverage and/or the tracking prior to the circularization burn should be improved, this sequence of events can be moved to the following day. However, if this is done the compressed time schedule that was achieved by this timeline will be sacrificed.

Table 7-1. Alternate Mission B-1a Spacecraft Events Summary

Event	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
Perform Transposition, Docking, and LM Ejection	03:43:00	00:45:00			100/100	---
All Crewmen Eat	04:55:00	01:00:00			100/100	---
IMU Alignment	06:20:00	00:20:00			100/100	---
Perform MCC Burn	06:50:00	00:00:05	SPS	34	130/100	RED
Perform LOI Burn	07:38:37	00:07:44	SPS	3724	400/130	GYM
IMU Alignment	08:00:00	00:20:00			400/130	---
Perform Circularization Burn	09:04:41	00:00:59	SPS	595	150/150	---
All Crewmen Sleep	09:30:00	07:00:00			150/150	---
All Crewmen Eat	17:00:00	01:00:00			150/150	---
IVT Preparation	18:00:00	00:50:00			150/150	---
LMP Transfers to LM	19:00:00	00:15:00			150/150	---
CDR Transfers to LM	20:30:00	00:10:00			150/150	---
CSM IMU Alignment	21:20:00	00:20:00			150/150	---
Deploy LM Landing Gear	22:00:00				150/150	---

Table 7-1. Alternate Mission B-1a Spacecraft Events Summary (Continued)

Event	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
LM IMU Alignment Course and Fine	23:00:00	00:25:00			150/150	---
First Docked DPS Burn (DOI)	24:15:00	00:01:09	DPS	40	150/150	CYI
LM IMU Alignment	24:30:00	00:20:00				---
Second Docked DPS Burn (MPD)	25:25:41	00:10:41	DPS	2848	165/150	WTN, GYM, US
CSM IMU Alignment	26:00:00	00:20:00				---
Orbit Trim Burn	26:25:00	00:00:02	SPS	37	150/150	CRO
Undock, CSM Active	26:50:00				150/150	HAW
Station Keeping	26:50:00	00:20:00			150/150	HAW, US-ETR
CSM/LM Separation	27:15:00	00:00:02	LM RCS	1	150/150	ETR, VAN
CSM IMU Alignment	27:20:00	00:20:00			150/150	---
LM IMU Alignment	27:40:00	00:20:00			150/150	---
LM Phasing Maneuver	28:40:00	00:00:31	DPS	79	159/136	GYM, US

Table 7-1. Alternate Mission B-1a Spacecraft Events Summary (Continued)

Event	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Events ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
CDH_1	31:23:00	00:00:12	DPS	41	159/159	GWM
Jettison Descent Stage	33:30:00				159/159	---
CSI	33:35:00	00:00:03	APS	34	158/140	---
CDH	34:21:00	00:00:03	APS	34	139/139	---
TPI	35:03:00	00:00:18	LM RCS	22	151/138	---
Initiate Braking Gates	35:32:00	00:00:19	LM RCS	23	151/146	---
LM Docks with CSM	36:04:00	00:05:00			150/150	MER
CDR Transfers to CSM	37:10:00	00:10:00			150/150	---
LMP Transfers to CSM	38:10:00	00:10:00			150/150	---
All Crewmen Eat	38:40:00	01:00:00			150/150	---
All Crewmen Sleep	39:40:00	07:00:00			150/150	---
All Crewmen Eat	46:40:00	01:00:00			150/150	---
LMP Transfers to LM	47:50:00	00:10:00			150/150	---
CSM IMU Alignment	48:20:00	00:20:00			150/150	---

Table 7-1. Alternate Mission B-1a Spacecraft Events Summary (Concluded)

Event	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Events ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
LM IMU Alignment	48:50:00	00:10:00			150/150	---
LMP Transfers to CSM	49:10:00	00:10:00			150/150	---
CSM IMU Realignment	50:00:00	00:20:00			150/150	---
CSM Undocks from Stable LM	50:28:00	00:00:02	SM RCS	1	150/150	CRO
CSM Phasing Burn	50:46:00	00:00:04	SPS	86	156/129	HAW
CSM Concentric Burn	51:56:00	00:00:02	SPS	48	156/156	CRO
TPI Burn	53:04:30	00:00:40	SM RCS	17	156/146	ACN
Initiate Braking Gates	53:32:24	00:00:36	SM RCS	15	150/147	---
Permanent Separation Burn	53:58:00	00:00:05	SM RCS	2	152/149	HAW
Continue 10 Day Mission Performing CSM Only Activities						

Table 7-2. Engine Burn Summary for Alternate Mission B-1a

Propulsion System	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Approximate Velocity Increment ΔV (fps)	Approximate Burn Time (sec)	Control Mode	Configuration
SPS	06:50:00	34	5	GNCS/LAPG	Docked
SPS	07:38:37	3724	464	GNCS/LAPG	Docked
SPS	09:04:41	595	59	GNCS/EXT ΔV	Docked
SPS	26:25:00	37	2	GNCS/EXT ΔV	Docked
SPS	50:46:00	86	4	GNCS/EXT ΔV	CSM Solo
SPS	51:56:00	48	2	GNCS/EXT ΔV	CSM Solo
SM RCS	50:28:00	1	2	Manual	CSM Solo
SM RCS	53:04:00	17	40	GNCS/LAPG	CSM Solo
SM RCS	53:32:24	15	36	Manual	CSM Solo
SM RCS	53:58:00	2	5	Manual	CSM Solo
DPS	24:15:00	40	69	PGNCS/EXT ΔV	Docked
DPS	25:25:41	2848	641	PGNCS/EXT ΔV	Docked
DPS	28:40:00	79	31	AGS/EXT ΔV	LM Solo
DPS	31:23:00	41	12	AGS/EXT ΔV	LM Solo
APS	33:35:00	34	3	PGNCS/EXT ΔV	LM Solo
APS	34:21:00	34	3	PGNCS/EXT ΔV	LM Solo
LM RCS	27:15:00	1	1	Manual	LM Solo
LM RCS	35:03:00	22	18	PGNCS/LAPG	LM Solo
LM RCS	35:32:00	23	19	Manual	LM Solo

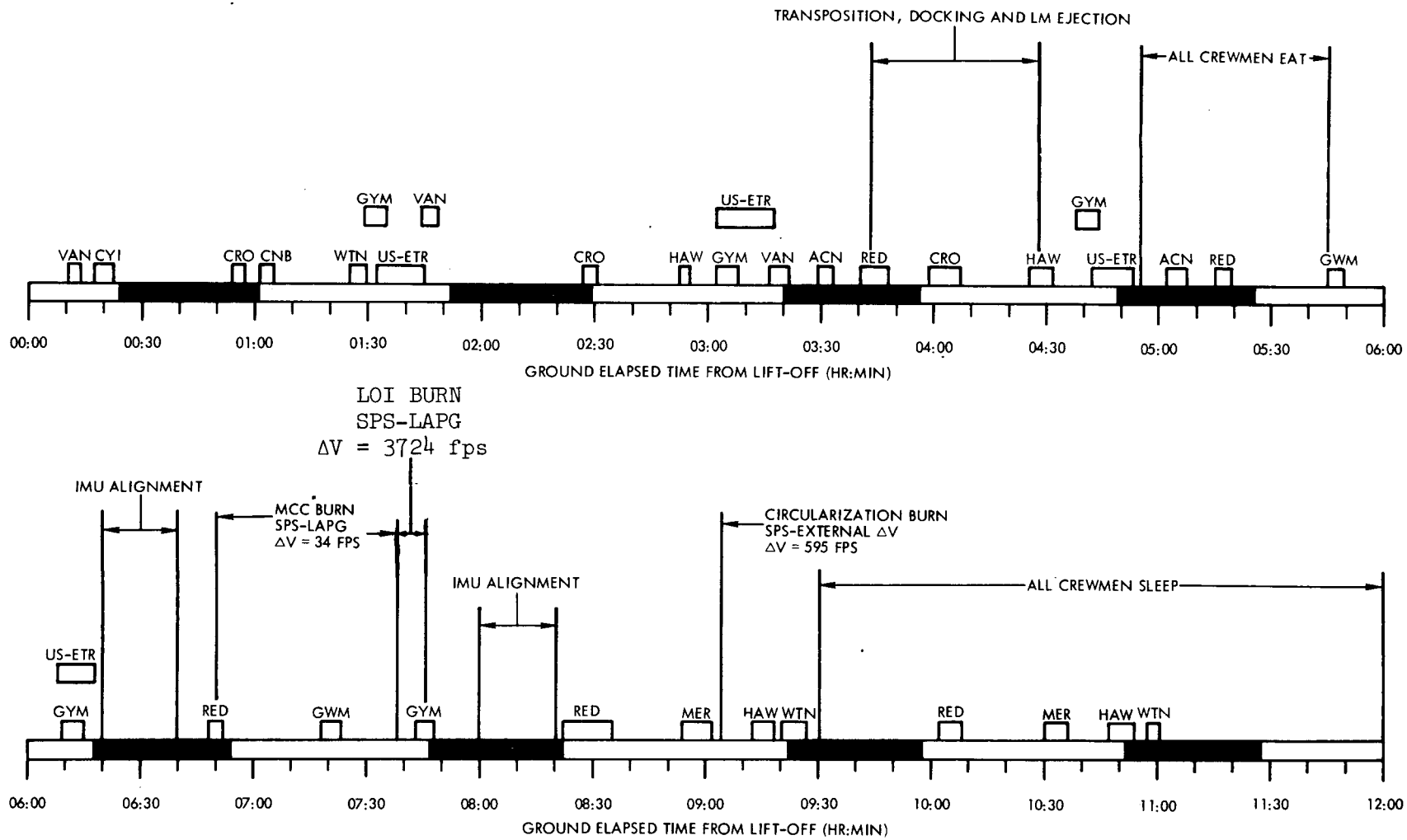


Figure 7-1. Alternate B-1a Mission Timeline

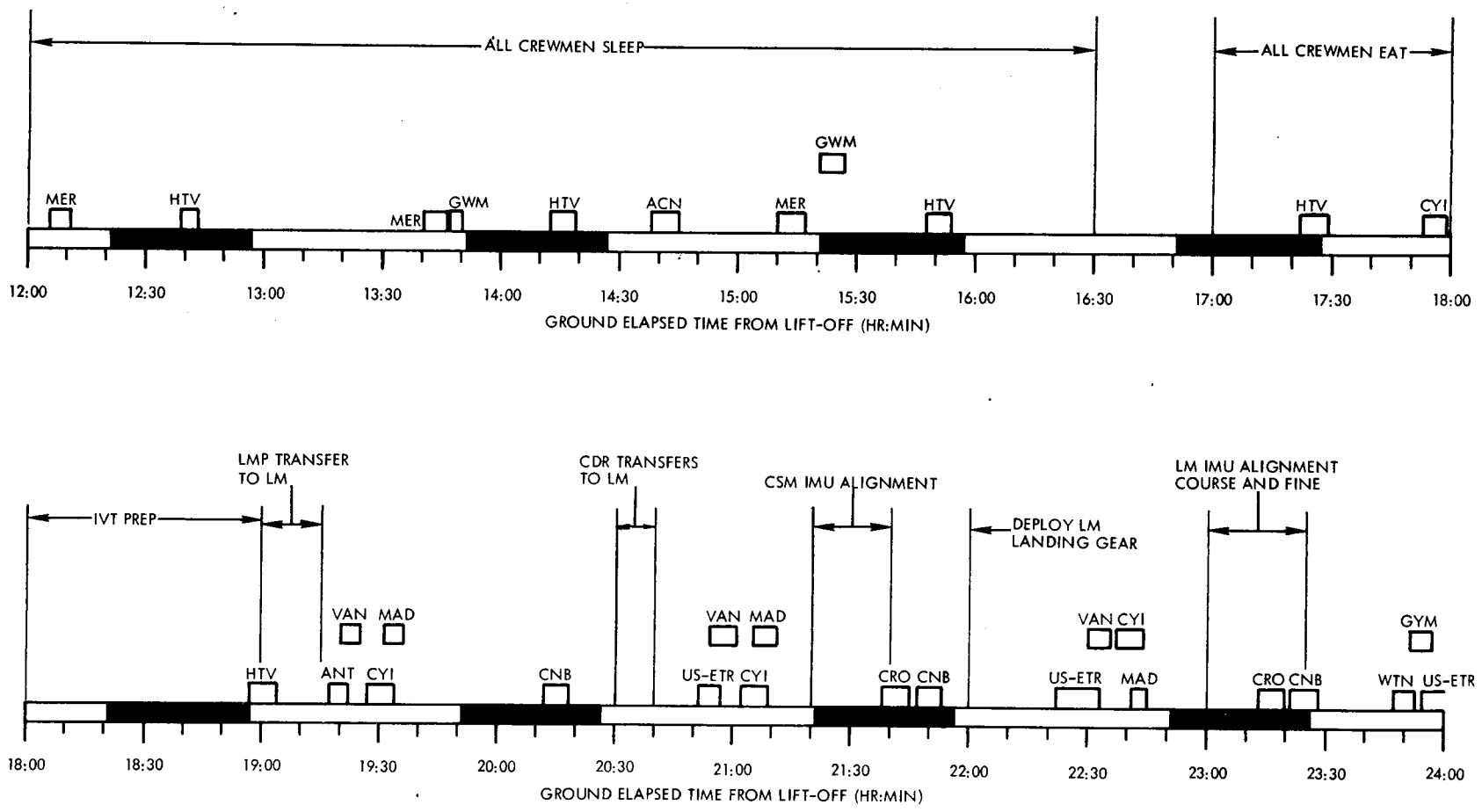


Figure 7-1. Alternate B-1a Mission Timeline (Continued)

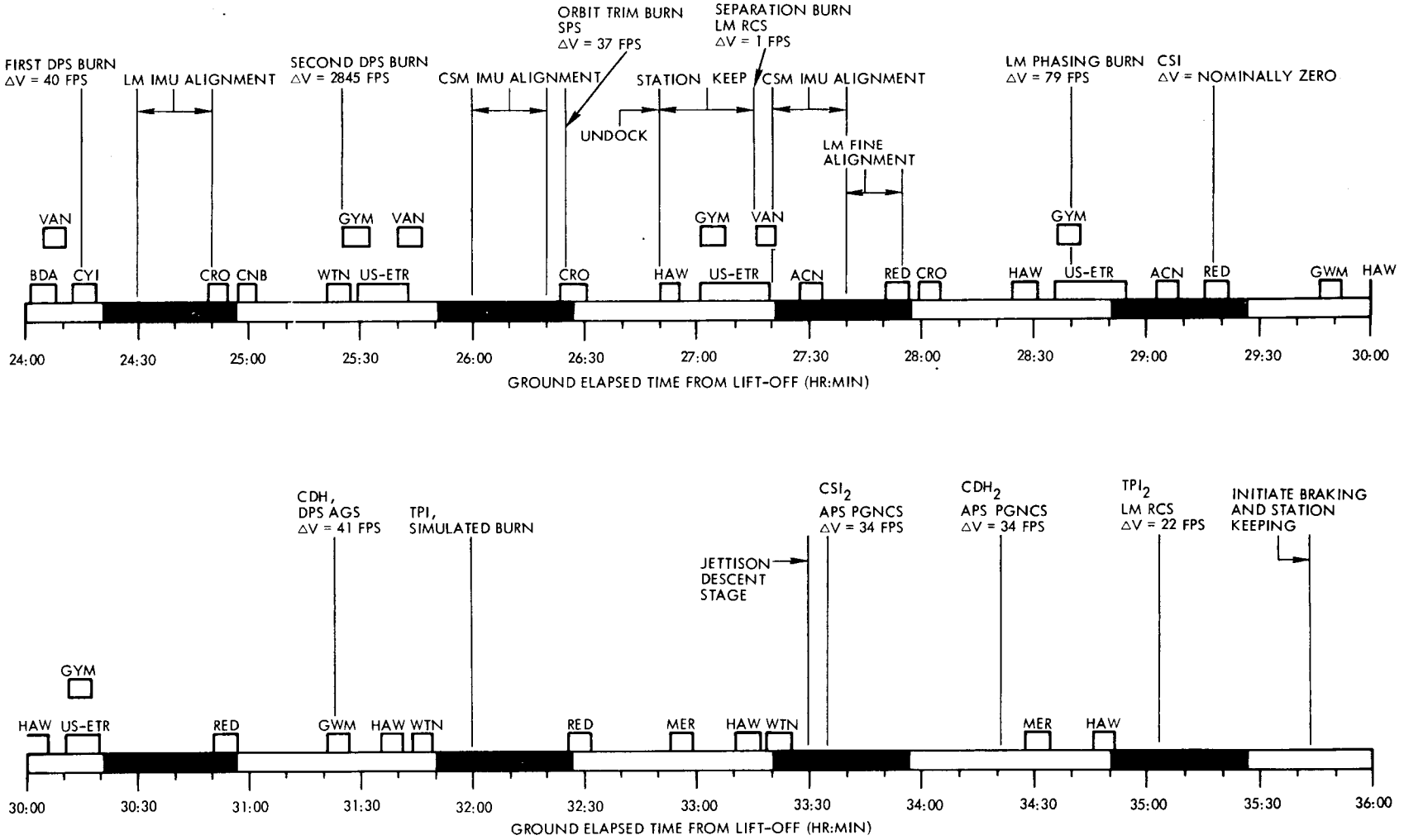
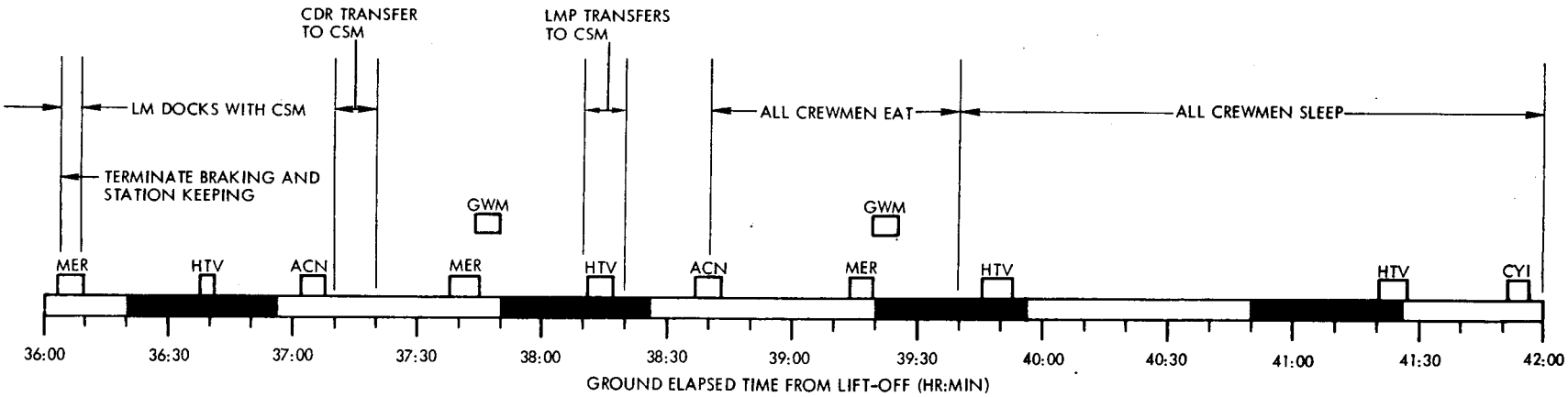


Figure 7-1. Alternate B-1a Mission Timeline (Continued)



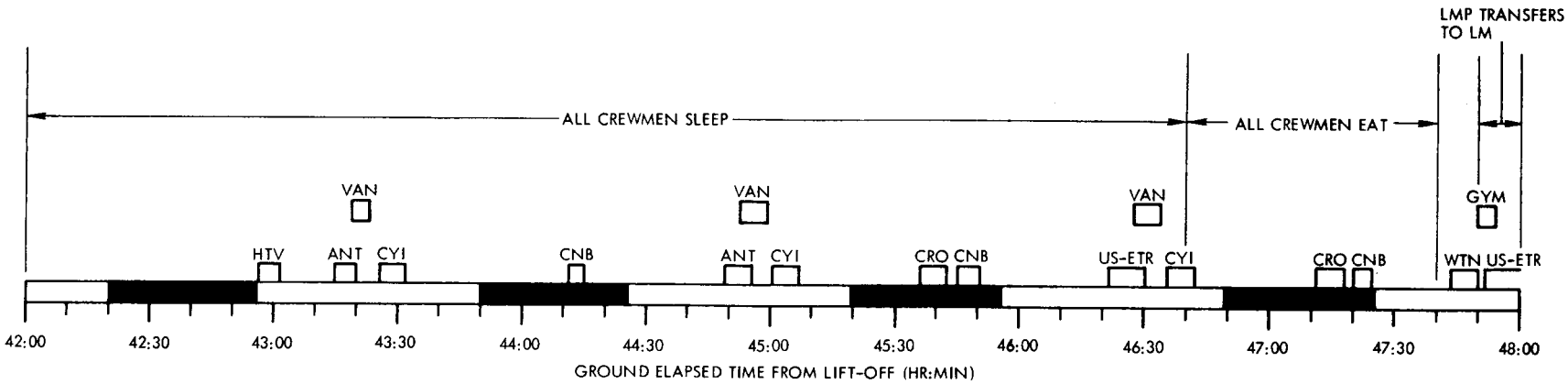


Figure 7-1. Alternate B-1a Mission Timeline (Continued)

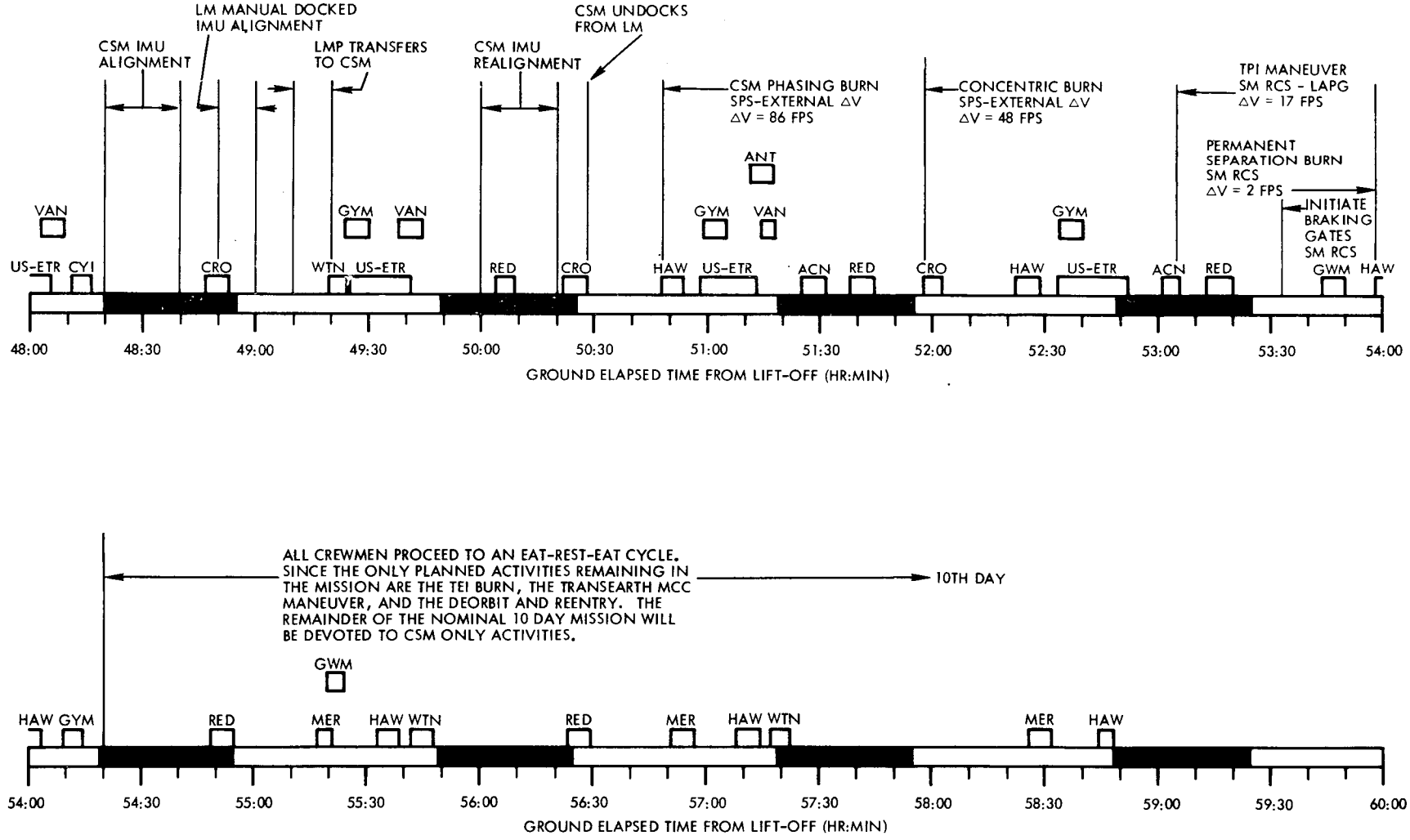


Figure 7-1. Alternate B-1a Mission Timeline (Concluded)

Alternate Mission C

7.3 ALTERNATE MISSION C

Alternate Mission C was designed to satisfy functional failure 5 (premature S-IVB cutoff during the TLI burn) and functional failure 4 (insufficient S-IVB propellants to accomplish nominal TLI burn). In the case of functional failure 5, the S-IVB burn was of such short duration as to yield a predicted apogee at cutoff of less than 2700 nautical miles. An apogee greater than 2700 nautical miles allows sufficient time to at least partially satisfy the two navigational DTO's, M20.58 and M20.59. Functional failure 4 covers the case where the Saturn S-II stage prematurely cuts off, thereby necessitating a longer S-IVB burn than was nominally planned for proper orbit insertion. Consequently, insufficient S-IVB propellants are remaining to perform the nominal TLI maneuvers, and the predicted apogee altitude attainable from a large S-IVB burn is not of sufficient magnitude (greater than 2700 nautical miles) to warrant a long burn. Therefore, in order to satisfy or partially satisfy the DTO's pertaining to the setup and performance of the TLI burn, a decision was made to burn the S-IVB for 25 seconds. This burn results in an apogee of 230 nautical miles.

Although the two functional failures described above do not appear to be similar enough to warrant the same alternate mission, they are similar. The orbit that results from functional failure 5 depends on the length of the S-IVB TLI burn. The orbit resulting from the 25-second S-IVB burn required for functional failure 4 is in fact one possible orbit resulting from a premature S-IVB TLI cutoff. Activities which follow either failure are identical, except for possible targeting changes associated with the subsequent SPS burns and tracking coverage changes caused by differences in the orbital period. The example timeline given has been tailored to the requirements of functional failure 4, (S-II underperformance) and as such may have direct application in real time. In any case, the following DTO's would be lost: M20.57 (CSM/MSFN High Altitude Communication), M20.58 (Star/Landmark Navigation), and M20.59 (Star/Earth Horizon Navigation). A spacecraft events summary and mission timeline are presented in Table 7-3 and Figure 7-2, respectively. An engine burn summary can be found in Table 7-4.

Period 1

Alternate C-1a is invoked in the first period of activities following one of the two functional failures mentioned above. In the event of a premature S-IVB cutoff, there are two reasons for reducing the apogee of the resulting elliptic orbit as soon as possible: (1) the MSFN coverage for the LOI burn may be partially or completely lost, and (2) the radiation dosage to the crew could prove to be hazardous. Transposition, docking, and LM ejection take place during the first apogee pass (nominally requires 45 minutes to complete). The IMU is aligned 45 degrees out-of-plane during the first darkness period for the first two SPS burns. As the spacecraft approaches second apogee, the crew prepare for and perform an SPS MCC burn, which results in raising the perigee to 130 nautical miles. Upon reaching second perigee, the simulated LOI burn, which has been retargeted to produce an apogee of 400 nautical miles, is performed. The burn is either posigrade or retrograde depending on the resultant orbit from the premature S-IVB cutoff. The pre-LOI apogee of the example given happens to be below 400 nautical miles, requiring a posigrade LOI maneuver. However, it should be recognized that functional failure 5 can result in a pre-LOI apogee of up to 2700 nautical miles, which would require a retrograde LOI maneuver. The excess ΔV from the LOI burn will be applied out-of-plane. At the proper point on the ellipse, just prior to perigee, an SPS burn is performed which circularizes the orbit at 150 nautical miles altitude.

Period 2

Since the high ellipse experiments were deleted from this alternate, the major mission events were brought forward in the mission. Therefore, the second period of activities will be devoted to performing the two docked DPS burns and the LM-active rendezvous.

Period 3

Upon completion of an eat-sleep-eat cycle following the activities of period 2, the crew prepares for and performs the CSM-active rendezvous with an unmanned LM ascent stage.

Nominal mission activities are followed from this point to the termination of the mission; however, these activities will be performed consistent with the new alternate C-1a mission timeline, Figure 7-2.

Table 7-3. Alternate Mission C-1a Spacecraft Events Summary

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
S-IVB Ingition and Shortened TLI Burn - 25 Seconds	03:16:30	00:00:25	S-IVB		230/100	US-ETR, VAN
Perform Transposition, Docking, and LM Ejection	03:43:30	00:45:00			230/100	---
IMU Alignment	04:55:00	00:15:00			230/100	---
Perform MCC Burn	05:36:00	00:00:05	SPS	34	230/130	CRO
Perform LOI Burn	06:17:31	00:07:44	SPS	3724	400/130	US-ETR, GYM
IMU Realignment	06:30:00	00:20:00			400/130	---
All Crewmen Eat	07:30:00	01:00:00			400/130	---
Circularize Orbit at 150 Nautical Miles	09:18:55	00:00:59	SPS	595	150/150	---
All Crewmen Sleep	10:00:00	07:00:00			150/150	---
All Crewmen Eat	17:00:00	01:00:00			150/150	---
IVT Preparation	18:00:00	00:50:00			150/150	---
LMP Transfers to LM	18:50:00	00:15:00			150/150	---
CDR Transfers to LM	20:00:00	00:10:00			150/150	---
CSM IMU Alignment	21:30:00	00:20:00			150/150	---

Table 7-3. Alternate Mission C-1a Spacecraft Events Summary (Continued)

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
Deploy LM Landing Gear	22:15:00				150/150	---
LM IMU Alignment	23:10:00	00:25:00			150/150	---
First DPS Burn (DOI)	24:25:00	00:01:09	DPS	40	150/150	CYI
LM IMU Alignment	24:40:00	00:20:00			150/150	---
Second DPS Burn (MPD)	25:35:41	00:10:41	DPS	2848	165/150	WTN, GYM, US
CSM IMU Alignment	26:00:00	00:20:00			165/150	---
Orbit Trim Burn	27:03:00	00:00:02	SPS	37	150/150	HAW
CSM IMU Alignment	27:30:00	00:20:00			150/150	---
LM IMU Alignment	27:50:00	00:20:00				
CSM/LM Undock and Station Keep	28:30:00	00:18:00	LM RCS	1	150/150	---
LM Phasing Burn	28:48:00	00:00:31	DPS	79	159/136	US, GYM
CDH Maneuver	31:30:00	00:00:12	DPS	41	159/159	---
Jettison Descent Stage	33:40:00				159/159	---
CSI_2 Burn	33:42:00	00:00:03	APS	34	158/140	---
CDH_2 Burn	34:28:00	00:00:03	APS	34	139/139	---

Table 7-3. Alternate Mission C-1a Spacecraft Events Summary (Concluded)

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
TPI_2 Burn	35:13:00	00:00:18	LM RCS	22	151/138	---
Initiate Braking Gates	35:42:00	00:00:19	LM RCS	23	151/146	---
LM Hard Dock With CSM	36:00:00				150/150	---
CDR Transfers to CSM	36:10:00	00:10:00			150/150	---
LMP Transfers to CSM	36:50:00	00:10:00			150/150	---
All Crewmen Eat	37:10:00	01:00:00			150/150	---
All Crewmen Sleep	38:10:00	07:00:00			150/150	---
All Crewmen Eat	45:30:00	01:00:00			150/150	---
LMP Transfers to LM	46:40:00	00:10:00			150/150	---
CSM IMU Alignment	47:00:00	00:20:00			150/150	---
LM Manual IMU Alignment	47:25:00	00:10:00			150/150	---
LMP Transfers to CSM	47:45:00	00:10:00			150/150	---
CSM IMU Alignment	48:30:00	00:20:00			150/150	---
CSM Undocks from LM	50:32:00	00:00:02	SM RCS	1	150/150	CRO
CSM Phasing Burn	50:57:00	00:00:04	SPS	86	156/129	HAW
CSM Concentric Burn	52:09:00	00:00:02	SPS	48	156/156	CRO
TPI Maneuver	53:15:00	00:00:40	SM RCS	17	156/146	ACN
Initiate Braking Gates	53:42:54	00:00:36	SM RCS	15	150/147	---
Permanent Separation Burn	54:02:00	00:00:05	SM RCS	2	152/149	---
Continue Mission Activities						

Table 7-4. Engine Burn Summary for Alternate Mission C-1a

Propulsion System	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Approximate Velocity Increment ΔV (fps)	Approximate Burn Time (sec)	Control Mode	Configuration
SPS	05:36:00	34	5	GNCS/LAPG	Docked
SPS	06:17:31	3724	464	GNCS/LAPG	Docked
SPS	09:18:55	595	59	GNCS/EXT ΔV	Docked
SPS	27:03:00	37	2	GNCS/EXT ΔV	Docked
SPS	50:57:00	86	4	GNCS/EXT ΔV	CSM Solo
SPS	52:09:00	48	2	GNCS/EXT ΔV	CSM Solo
SM RCS	50:32:00	1	2	Manual	CSM Solo
SM RCS	53:15:00	17	40	GNCS/LAPG	CSM Solo
SM RCS	53:42:54	15	36	Manual	CSM Solo
SM RCS	54:02:00	2	5	Manual	CSM Solo
DPS	24:25:00	40	69	PGNCS/EXT ΔV	Docked
DPS	25:35:41	2848	641	PGNCS/EXT ΔV	Docked
DPS	28:48:00	79	31	AGS/EXT ΔV	LM Solo
DPS	31:30:00	41	12	AGS/EXT ΔV	LM Solo
APS	33:42:00	34	3	PGNCS/EXT ΔV	LM Solo
APS	34:28:00	34	3	PGNCS/EXT ΔV	LM Solo
LM RCS	28:30:00	1	1	Manual	LM Solo
LM RCS	35:13:00	22	18	PGNCS/LAPG	LM Solo
LM RCS	35:42:00	23	19	Manual	LM Solo

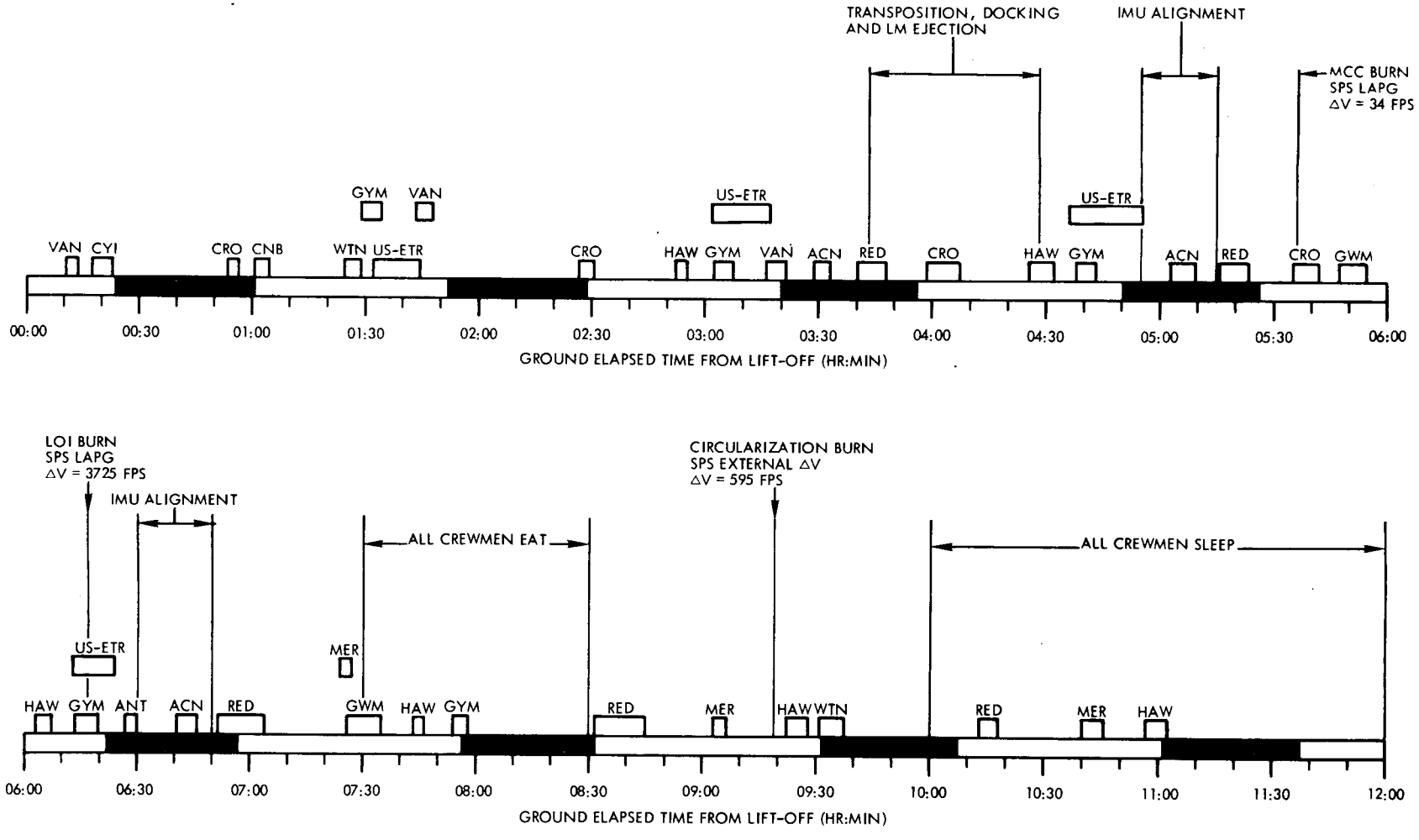


Figure 7-2. Alternate C-1a Mission Timeline

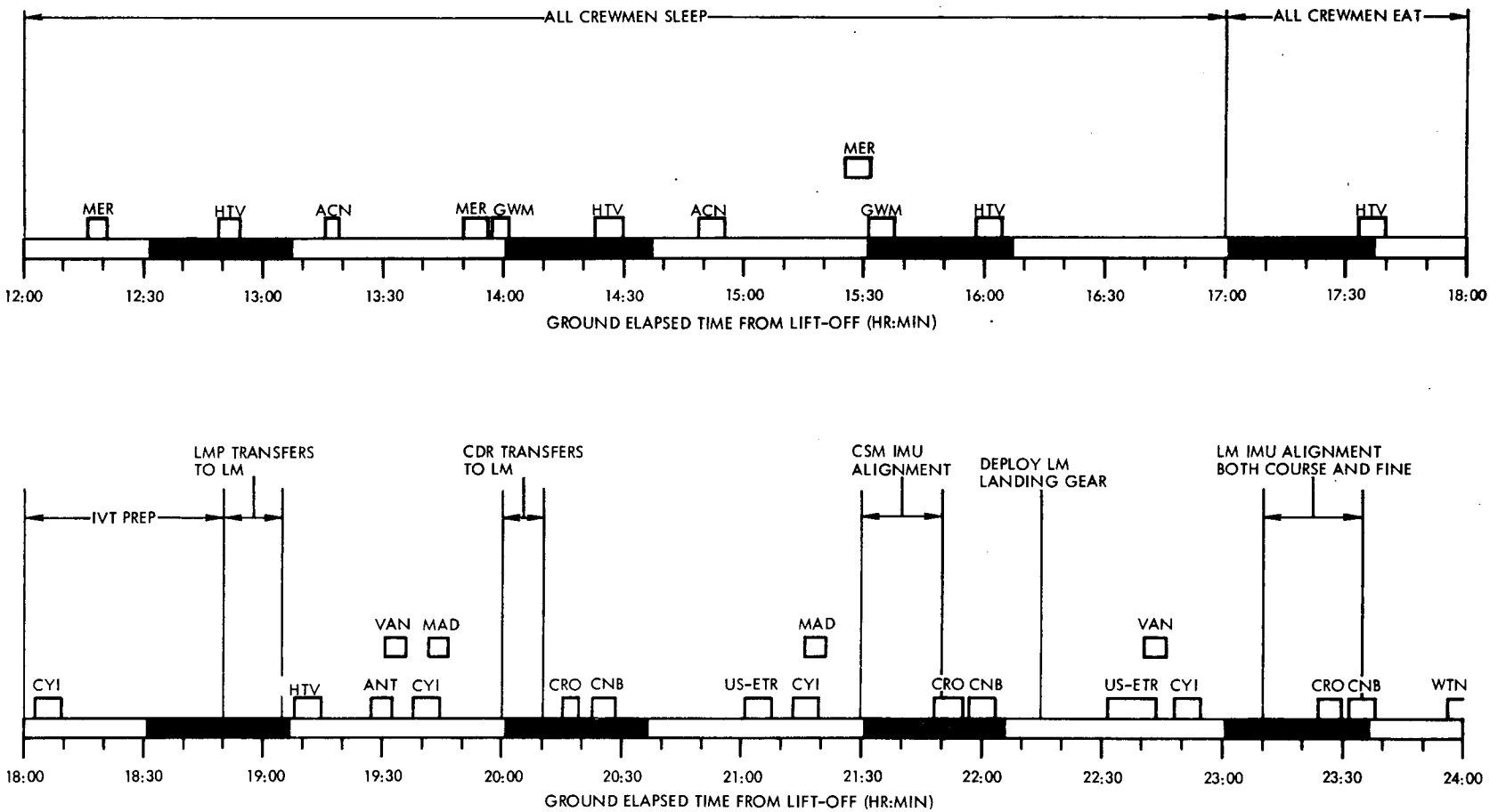


Figure 7-2. Alternate C-1a Mission Timeline (Continued)

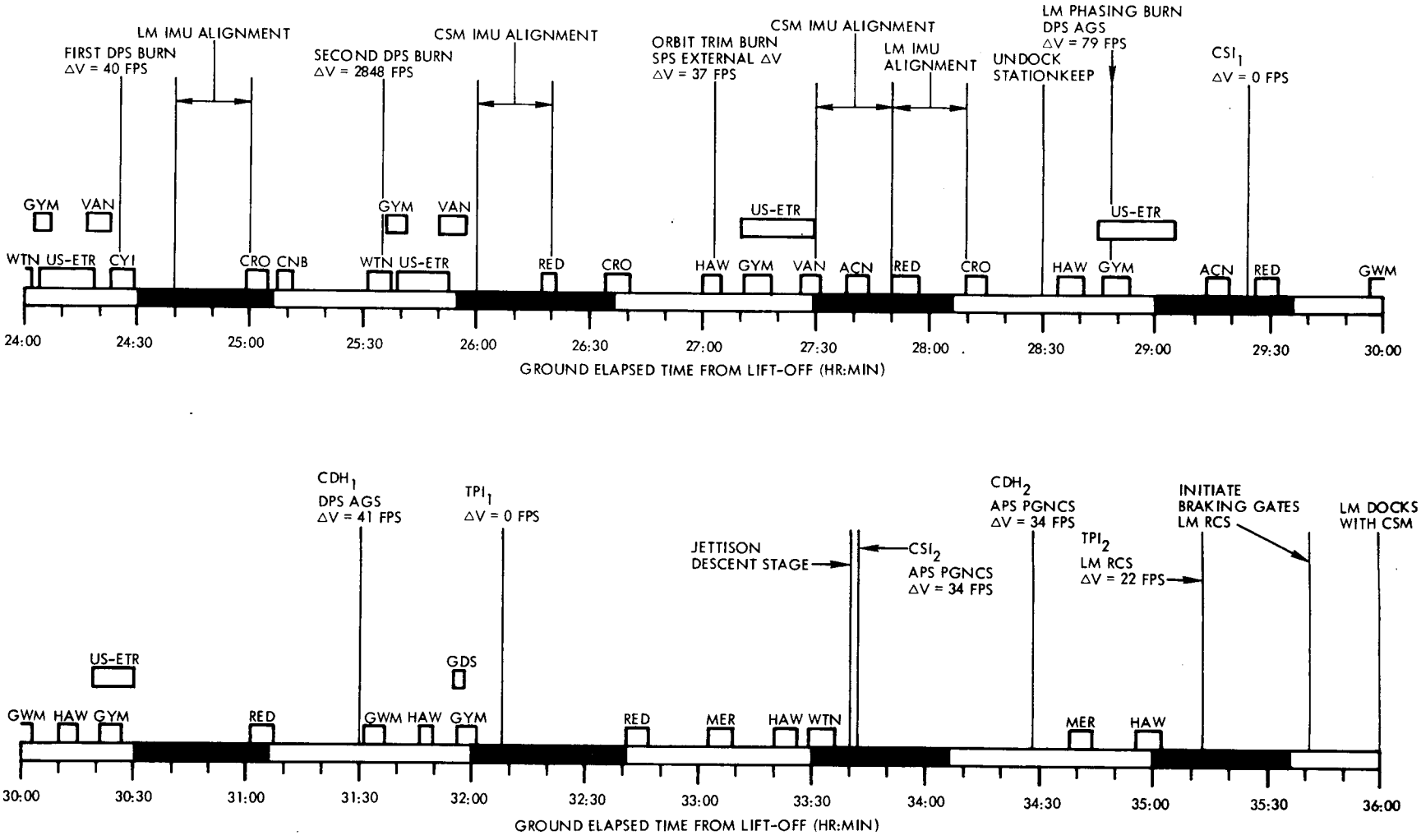


Figure 7-2. Alternate C-1a Mission Timeline (Continued)

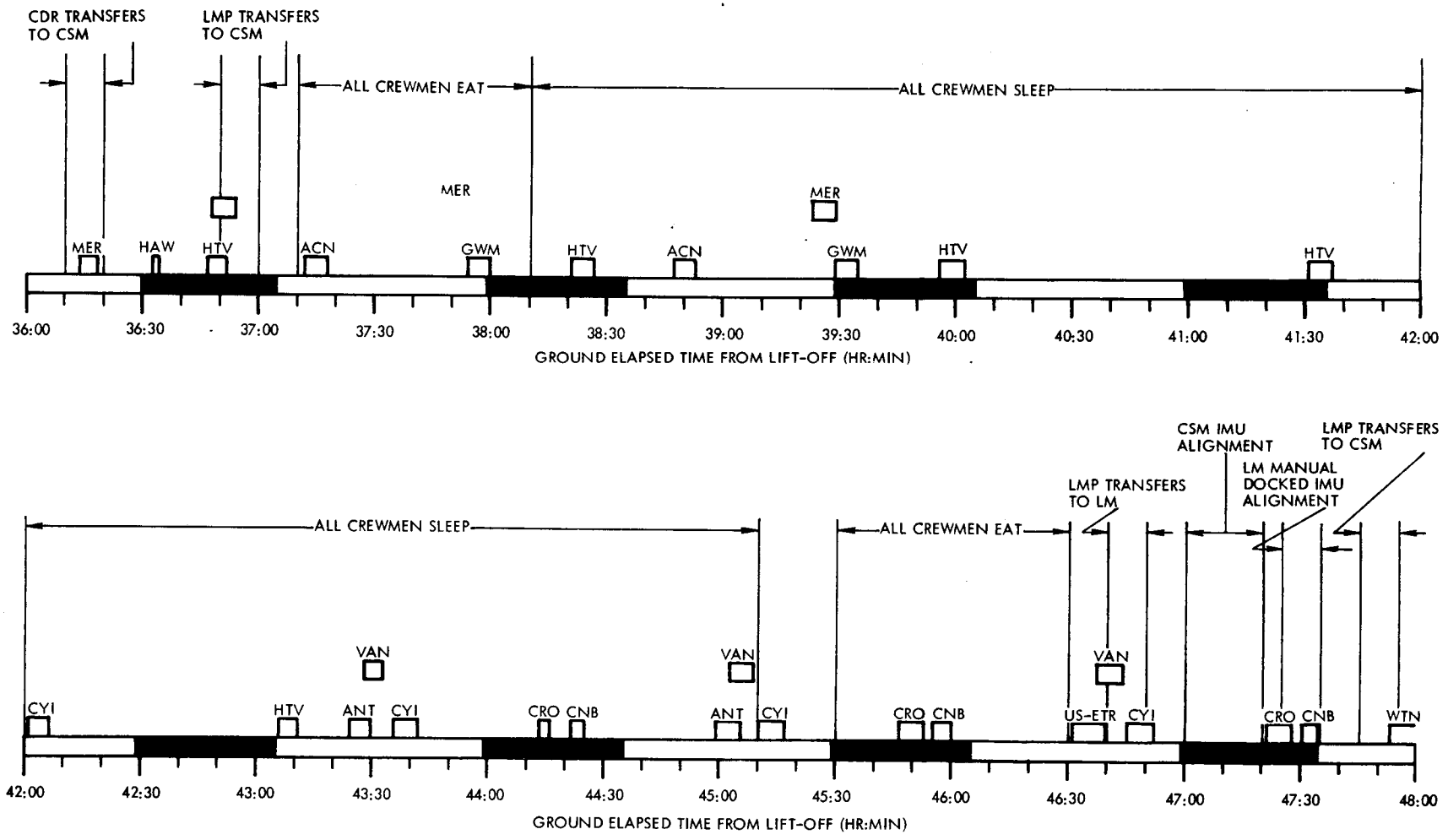


Figure 7-2. Alternate C-1a Mission Timeline (Continued)

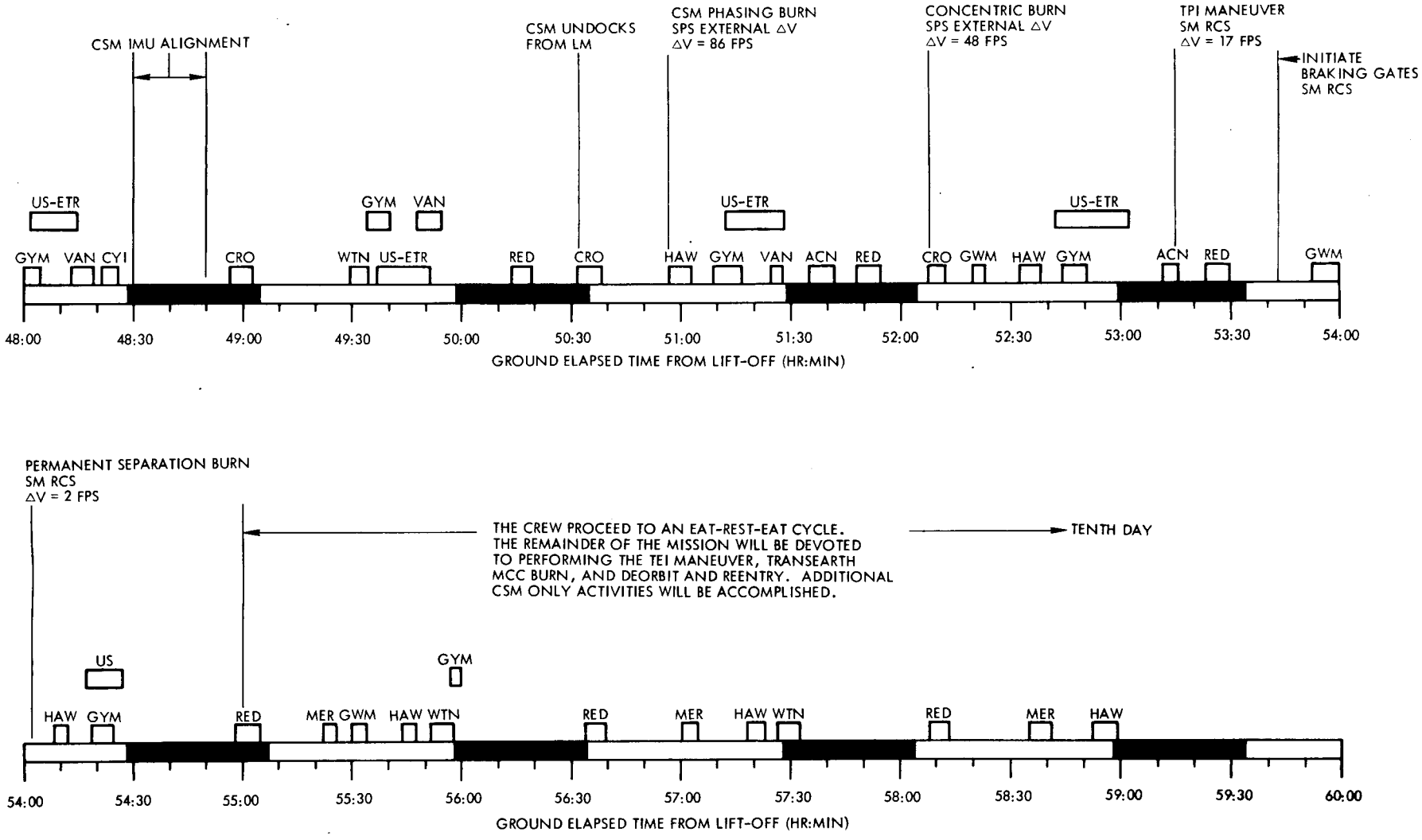


Figure 7-2. Alternate C-1a Mission Timeline (Concluded)

Alternate Mission D

7.4 ALTERNATE MISSION D

Alternate Mission D is presented for the case where, following insertion and prior to the S-IVB TLI burn, a CSM system has partially failed and a limited systems lifetime has been established (functional failure 6). This alternate was designed to accomplish the high priority mandatory DTO's; the mandatory DTO's not satisfied by this alternate are: M20.57 (CSM/LM High Altitude Communication), M20.58 (Star/Landmark Navigation), and 20.59 (Star/Earth Horizon Navigation). A spacecraft events summary and mission timeline, including tracking and lighting coverage, are presented in Table 7-5 and Figure 7-3, respectively. Table 7-6 presents the engine burn summary for this alternate.

Period 1

Alternate Mission D is initiated during the first period of activities when, following insertion and just prior to the TLI burn, a CSM system degradation has been substantiated. Upon confirmation of a CSM system lifetime problem, transposition, docking, and LM ejection are performed while in the low insertion orbit. Following CSM/LM ejection, the crew proceeds to an eat period. Upon completion of the eat period, the IMU is aligned 45 degrees out-of-plane and the crew prepares for the SPS MCC burn. This burn has the effect of changing the original 100-nautical mile circular orbit to a 130- by 100-nautical mile ellipse. As the spacecraft approaches apogee, the crew prepares for the LOI burn. This burn is targeted so that the resulting orbit is characterized by a 400-nautical mile apogee and a 130-nautical mile perigee with the excess ΔV applied out-of-plane. Upon completion of the LOI burn, preparation is made for a third SPS burn. This burn is utilized to circularize the orbit at 150 nautical miles and is targeted to occur just prior to perigee. All crewmen begin a sleep cycle following the circularization burn.

Period 2

Following an eat period, the LMP and CDR prepare for intravehicular transfer (IVT). The LMP transfers to the LM and initiates LM systems checkout. The CDR then transfers to the LM in preparation for the docked DPS burns. Prior to the burns, the LM landing gear is deployed and the IMU is aligned (both course and fine). The first docked

DPS burn is designed to simulate the DOI burn. The ΔV from this burn is directed out-of-plane. The DOI burn is followed by the simulation of the MPD burn. The majority of the burn is directed out-of-plane except for a small ΔV forward component. This forward component changes the 150-nautical mile circular orbit to a 165- by 150-nautical mile ellipse. These two docked DPS burns are followed by an SPS trim burn, which trims the orbit to a 150-nautical mile circular orbit. Upon completion of the trim burn, the CSM and LM undock and proceed to the LM-active rendezvous. Following the rendezvous, the LMP and CDR transfer to the CSM, which permanently separates from the LM. Upon completion of the separation maneuver, the crew prepares for and performs the deorbit maneuver.

This alternate can be accomplished in approximately 36 to 40 hours from liftoff to reentry.

Table 7-5. Alternate Mission D-1a Spacecraft Events Summary

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
Perform Transposition, Docking, and LM Ejection	03:43:30	00:45:00			100/100	---
All Crewmen Eat	04:45:00	01:00:00			100/100	---
IMU Alignment	06:10:00	00:20:00			100/100	---
Perform MCC burn	06:50:00	00:00:05	SPS	34	130/100	RED
Perform LOI Burn	07:34:27	00:07:44	SPS	3724	400/130	HAW, GDS
IMU Alignment	08:00:00	00:20:00				
Circularize Orbit at 150 Nautical Miles	09:01:04	00:00:59	SPS	595	150/150	MER
All Crewmen Sleep	09:30:00	07:00:00			150/150	---
All Crewmen Eat	16:30:00	01:00:00			150/150	---
Pre-IVT Activities	17:30:00	00:40:00			150/150	---
LMP Transfers to LM	18:10:00	00:15:00			150/150	---
CDR Transfers to LM	19:20:00	00:10:00			150/150	---
IMU Alignment	19:50:00	00:20:00			150/150	---

Table 7-5. Alternate Mission D-1a Spacecraft Events Summary (Concluded)

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
Deploy LM Landing Gear	20:30:00	00:05:00			150/150	---
LM IMU Alignment - Both Course and Fine	21:20:00	00:25:00			150/150	---
Perform First DPS Burn (DOI)	22:40:00	00:01:09	DPS - 10%	40	150/150	MAD
LM IMU Alignment	23:00:00	00:20:00				---
Perform Second DPS Burn (MPD)	23:51:21	00:10:40	DPS	2845	165/150	WTN, GYM, US
CSM IMU Alignment	24:25:00	00:20:00				---
Orbit Trim Burn	24:50:00	00:00:02	SPS	37	150/150	CRO
CSM Undocks from LM and Prepares for Either the Nominal Rendezvous, or a Modified Rendezvous Designed to Accomplish All Mandatory Rendezvous Related DTO's.	25:30:00				150/150	GYM, US
Deorbit Maneuver Will Be Performed at the First Opportunity		To be Determined				

Table 7-6. Engine Burn Summary for Alternate Mission D-1a

Propulsion System	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Approximate Velocity Increment ΔV (fps)	Approximate Burn Time (sec)	Control Mode	Configuration
SPS	06:50:00	34	5	GNCS/LAPG	Docked
SPS	07:34:27	3724	464	GNCS/LAPG	Docked
SPS	09:01:04	595	59	GNCS/EXT ΔV	Docked
SPS	24:50:00	37	2	GNCS/EXT ΔV	Docked
SM RCS*					
DPS*		40	69	PGNCS/EXT ΔV	Docked
DPS	23:51:21	2845	640	PGNCS/EXT ΔV	Docked
LM RCS*					

*Burns could be required of these systems during the modified rendezvous portion of this alternate. However, the modified rendezvous has not yet been defined.

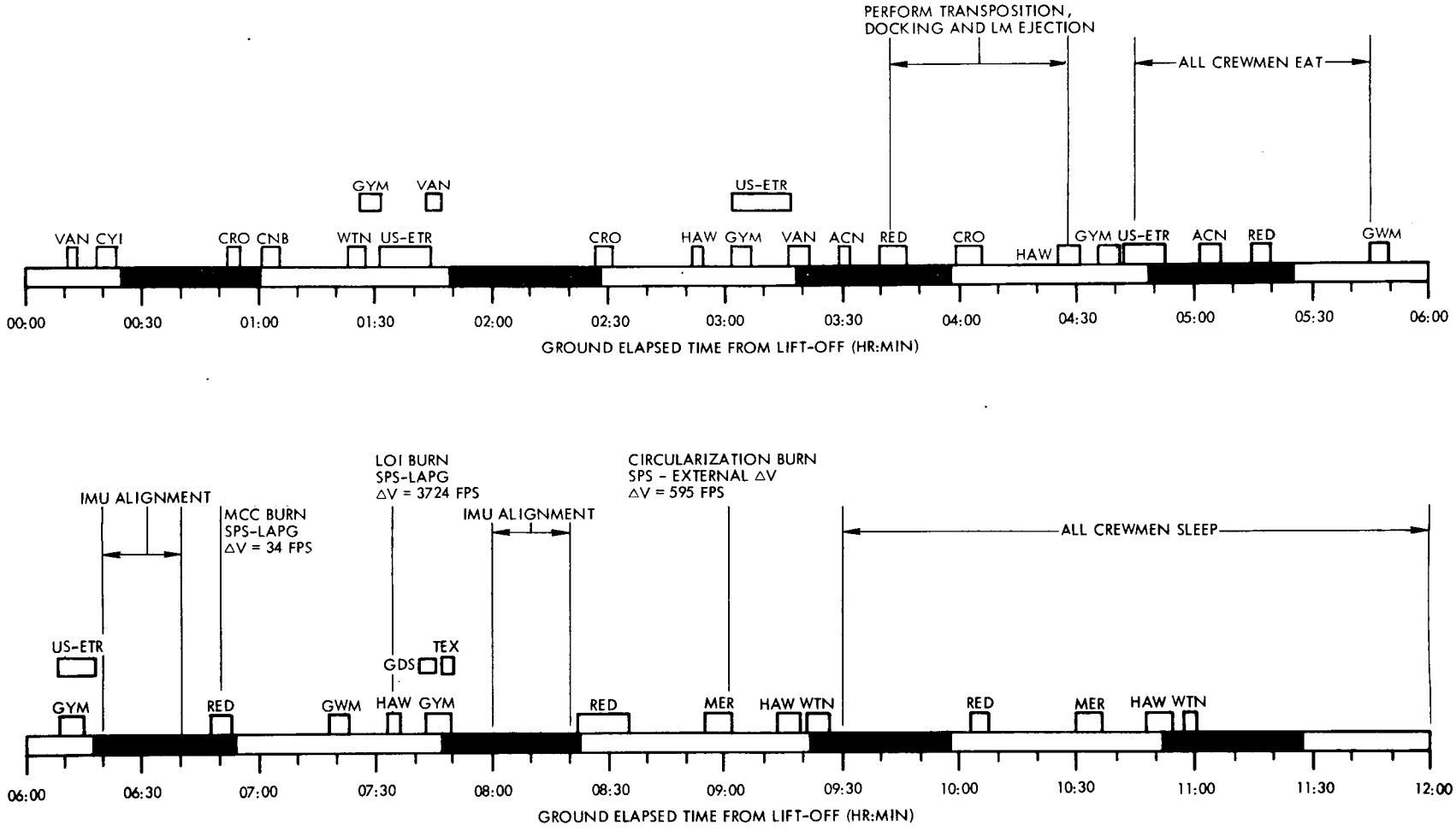


Figure 7-3. Alternate D-1a Mission Timeline

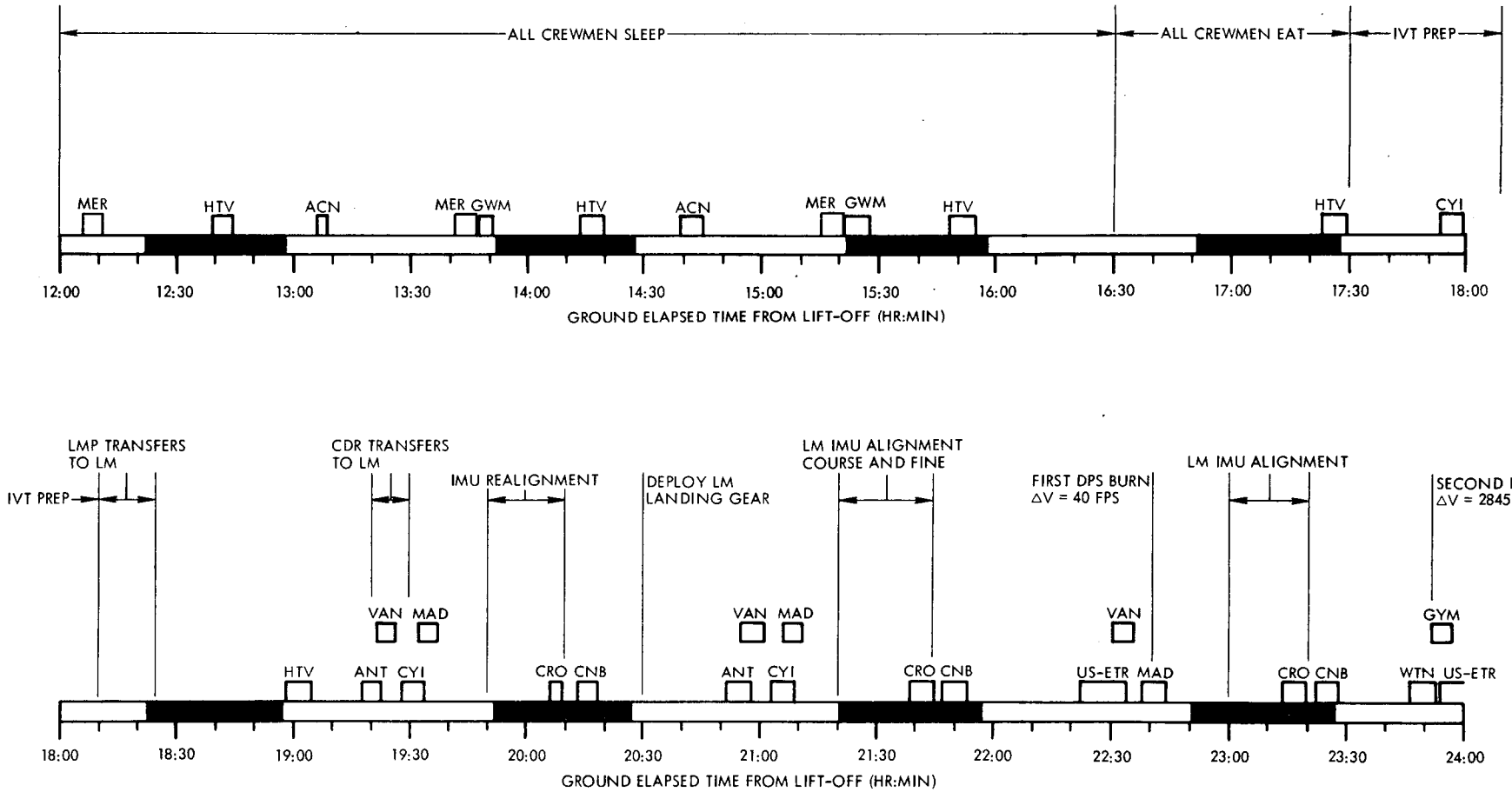


Figure 7-3. Alternate D-1a Mission Timeline (Continued)

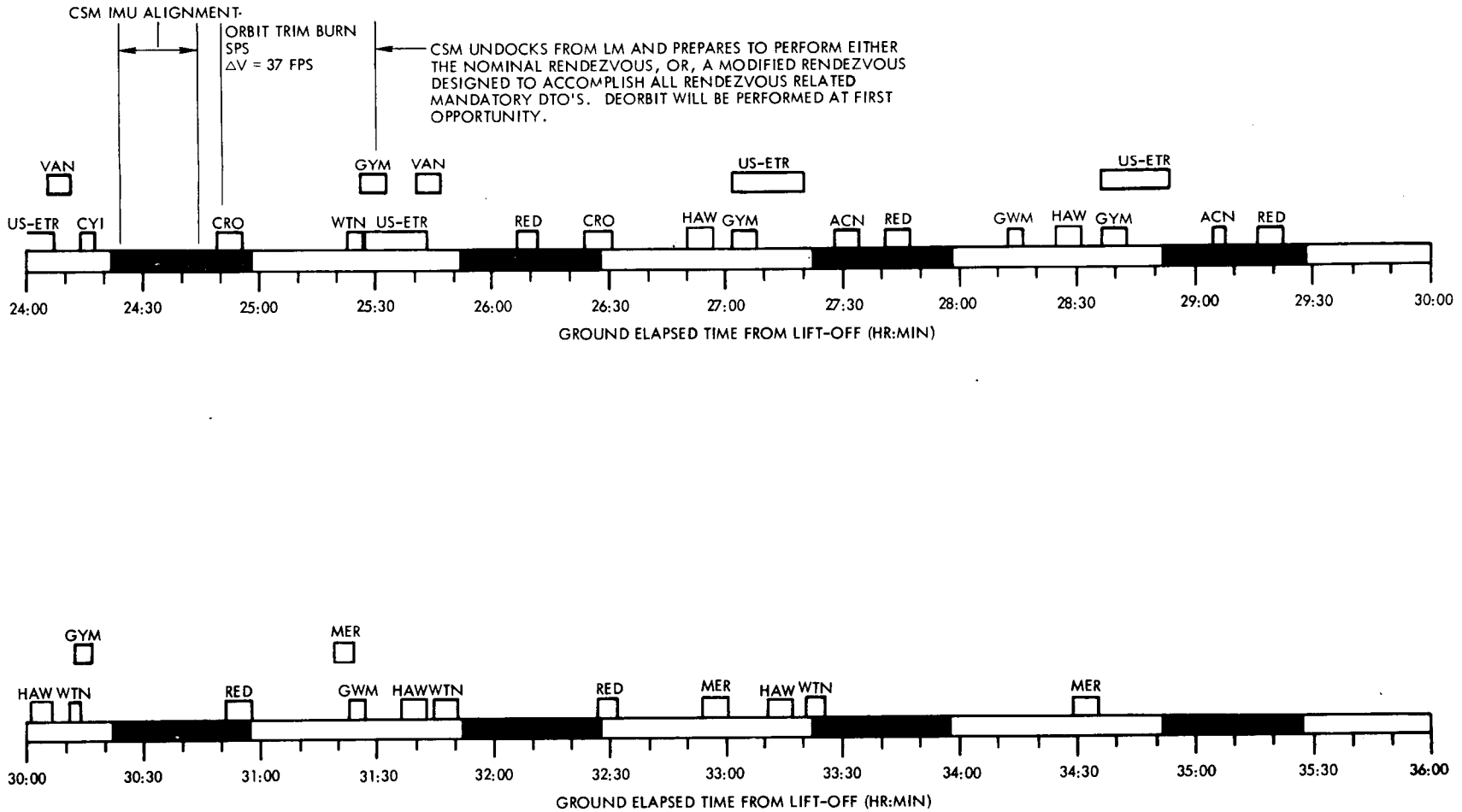


Figure 7-3. Alternate D-1a Mission Timeline (Concluded)

Alternate Mission E

7.5 ALTERNATE MISSION E

Alternate Mission E is designed to accommodate functional failure 8 (LM ECS primary coolant loop failure). Nominal mission events will be performed up to the LM systems checkout in the second period of activities, which presents the earliest opportunity to recognize a failure of this type. The two docked DPS burns, which are nominally performed following the LM systems checkout, will be deleted in light of this failure. In addition, the LM-active rendezvous, nominally performed in the third period of activities, will also be deleted. The following mandatory DTO's will be lost by performing this alternate mission: M20.48 (LM Abort/Nominal Rendezvous) and M20.45 (Simulated TOI/Descent Burns). The spacecraft events summary and the mission timeline for the alternate are presented in Table 7-7 and Figure 7-4 respectively. Engine burn summaries are provided in Table 7-8.

Period 2

Alternate Mission E is initiated in the second period of activities when a failure in the LM ECS primary coolant loop is detected. The two docked DPS burns planned for this period will be deleted, since this type of failure would eventually cause extensive damage to the PGNCS from overheating; therefore, a switch to the AGS is necessitated. Based on the latest information available (Reference 8), the docked DPS burns cannot be controlled by the AGS, therefore, they must be deleted.

Period 3

This period of activities is nominally devoted to the accomplishment of a LM active rendezvous. Undocked operation will not be attempted without a primary coolant loop. Therefore, the CSM-active rendezvous with an inertially stabilized unmanned LM (nominal period 4 activities) will be brought forward to this period of activities.

Period 4

Since the CSM-active rendezvous, which was to be performed during this period, was moved forward to the third period, this period is devoted to performing the TEI simulation maneuver, and the transearth MCC maneuver. The remainder of the 10 day mission is devoted to "CSM only" activities prior to deorbiting at the nominal time.

Table 7-7. Alternate Mission E-2a Spacecraft Events Summary

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
CDR Transfers to LM	48:00:00	00:10:00			150/150	---
LM IMU Alignment	48:30:00	00:15:00			150/150	---
LMP Transfers to CSM	48:45:00	00:10:00			150/150	---
All Crewmen Eat	48:55:00	01:00:00			150/150	---
CSM IMU Alignment	50:00:00	00:20:00			150/150	---
CSM Undocks from Stabilized LM	50:30:00	00:00:02	SM RCS	1	150/150	---
CSM Phasing Burn	50:47:00	00:00:04	SPS	86	156/129	HAW
CSM Concentric Burn	51:58:00	00:00:02	SPS	48	156/156	CRO
TPI Maneuver	53:07:00	00:00:40	SM RCS	17	156/146	ACN
Initiate Braking Gates	53:34:54	00:00:36	SM RCS	15	150/147	---
Permanent Separation Burn	54:00:00	00:00:05	SM RCS	2	152/149	---
All Crewmen Eat and Sleep and Continue Mission	54:10:00					

Table 7-8. Engine Burn Summary for Alternate Mission E-2a

Propulsion System	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Approximate Velocity Increment ΔV (fps)	Approximate Burn Time (sec)	Control Mode	Configuration
SPS	50:47:00	86	4	GNCS/EXT ΔV	CSM Solo
SPS	51:58:00	48	2	GNCS/EXT ΔV	CSM Solo
SM RCS	50:30:00	1	2	Manual	CSM Solo
SM RCS	53:07:00	17	40	GNCS/LAPG	CSM Solo
SM RCS	53:34:54	15	36	Manual	CSM Solo
SM RCS	54:00:00	2	5	Manual	CSM Solo

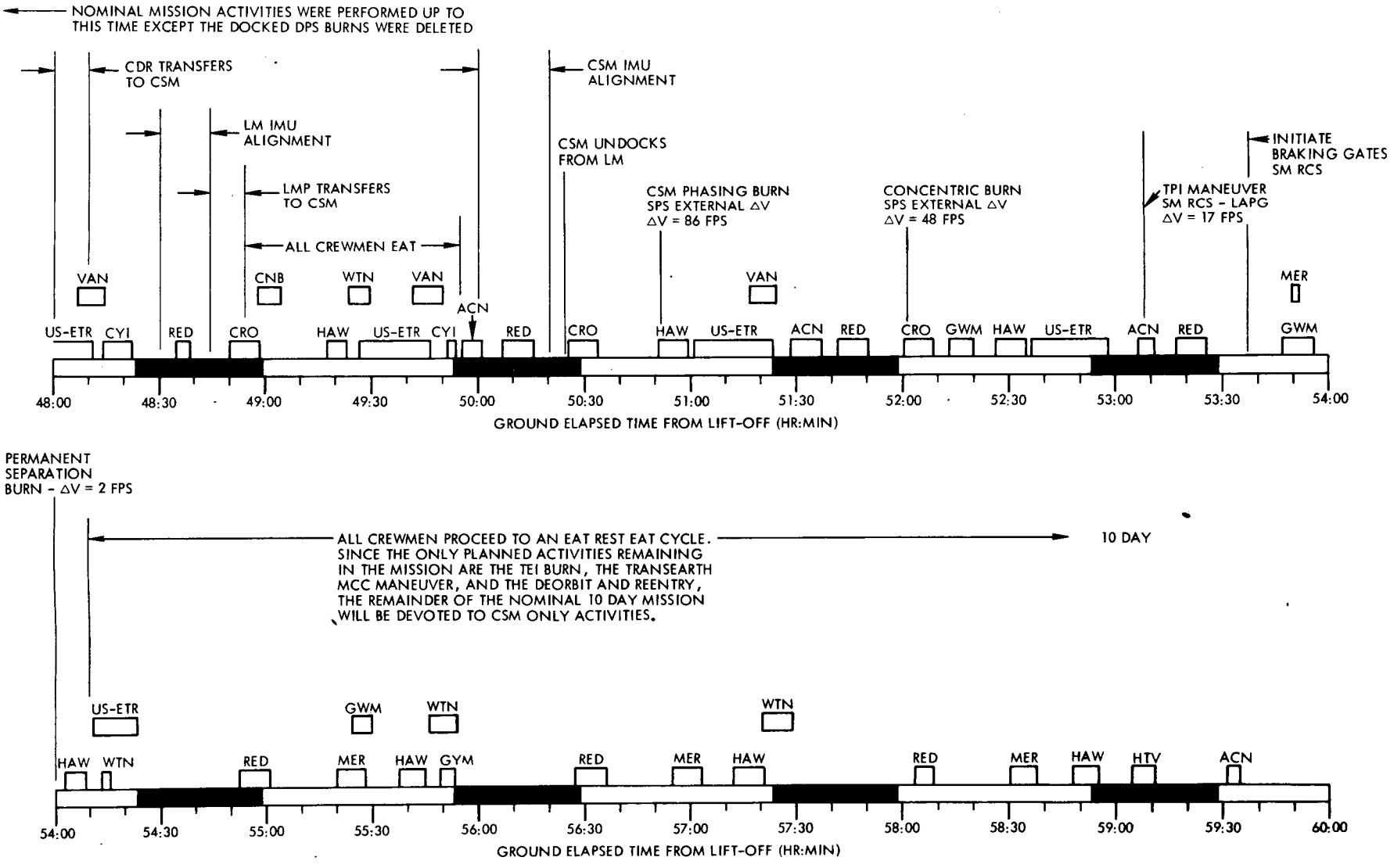


Figure 7-4. Alternate E-2a Mission Timeline

Alternate Mission F

7.6 ALTERNATE MISSION F

Alternate Mission F, functional failure 9 (LM PGNCS failure), is very similar to alternate E. Nominal mission events are performed up to the LM systems checkout in the second period of activities, which affords the earliest opportunity to recognize a failure of this type. The two docked DPS burns are deleted in light of this failure. The LM-active rendezvous, nominally performed in the third period of activities, will be deleted. However, a modified rendezvous consisting of a station keeping exercise will be substituted for the LM-active rendezvous. A station keeping exercise will allow limited manned LM operations which could partially satisfy the LM Abort/Nominal Rendezvous (M20.48) DTO. The Simulated TOI Descent Burns (M20.45) DTO will be lost by deleting the docked DPS burns. The spacecraft events summary and the mission timeline for this alternate are presented in Table 7-9 and Figure 7-5, respectively. An engine burn summary is presented in Table 7-6.

Period 2

Alternate Mission F is invoked in the second period of activities and is precipitated by a failure of the LM PGNCS. The two docked DPS burns planned for this period will be deleted based on the information presented in Reference 8. Reference 8 states that the AGS lacks the control required for a docked DPS burn.

Period 3

This period is devoted to the performance of the LM-active rendezvous. The rendezvous maneuvers are to be controlled by the AGS with the PGNCS used as a backup. However, with a loss of the PGNCS it is highly unlikely that extended undocked manned LM operations would be undertaken. A modified rendezvous consisting of a station keeping exercise is performed in lieu of the nominal rendezvous. This limited exercise would afford some experience in manned undocked LM operation. The remainder of the nominal mission activities will be performed following the timeline in Figure 7-5.

Table 7-9. Alternate Mission F-2a Spacecraft Events Summary

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
CSM IMU Alignment	48:25:00	00:20:00			150/150	---
Undock and Perform Modified Rendezvous (probably limited to station keeping)	49:27:00				150/150	US-ETR, WTN
Jettison Descent Stage	51:10:00				150/150	US-ETR
LM Docks with CSM	52:30:00				150/150	HAW
CDR Transfers to CSM	53:30:00	00:10:00			150/150	---
LMP Transfers to CSM	54:30:00	00:10:00			150/150	---
All Crewmen Eat	55:00:00	01:00:00			150/150	---
All Crewmen Sleep	56:30:00	08:00:00			150/150	---
All Crewmen Eat	64:30:00	01:00:00			150/150	---
LMP Transfers to LM	65:50:00	00:20:00			150/150	---
CSM IMU Alignment	66:25:00	00:20:00			150/150	---
LM Manual Docked IMU Alignment	66:50:00	00:10:00			150/150	---

Table 7-9. Alternate Mission F-2a Spacecraft Events Summary (Concluded)

Event	Ground Elapsed Time at Initiation (hr:min:sec)	Duration of Event ΔT (hr:min:sec)	Propulsion System	ΔV (fps)	Resulting h_a/h_p (n mi)	Tracking
LMP Transfers to CSM	67:20:00	00:10:00			150/150	---
CSM IMU Alignment	68:00:00	00:20:00			150/150	---
CSM Undocks from Stable LM	68:26:00	00:00:02	SM RCS	1	150/150	---
CSM Phasing Burn	68:49:00	00:00:04	SPS	86	156/129	US
CSM Concentric Burn	70:00:00	00:00:02	SPS	48	156/156	US-ETR
TPI Maneuver	71:09:00	00:00:40	SM RCS	17	156/146	---
Initiate Braking Gates	71:36:54	00:00:36	SM RCS	15	150/147	---
Permanent Separation Burn	72:18:00	00:00:05	SM RCS	2	152/149	CYI
All Crewmen Eat and Sleep and Continue Mission						

Table 7-10. Engine Burn Summary for Alternate Mission F-2a

Propulsion System	Approximate Ground Elapsed Time at Initiation (hr:min:sec)	Approximate Velocity Increment ΔV (fps)	Approximate Burn Time (sec)	Control Mode	Configuration
SPS	68:49:00	86	4	GNCS/EXT ΔV	CSM Solo
SPS	70:00:00	48	2	GNCS/EXT ΔV	CSM Solo
SM RCS	68:50:00	1	2	Manual	CSM Solo
SM RCS	71:09:00	17	40	GNCS/LAPG	CSM Solo
SM RCS	71:36:54	15	36	Manual	CSM Solo
SM RCS	72:18:00	2	5	Manual	CSM Solo
LM RCS*					
APS*					
DPS*					

*Burns could be required of these systems during the modified rendezvous portion of this alternate. However, the modified rendezvous has not yet been defined.

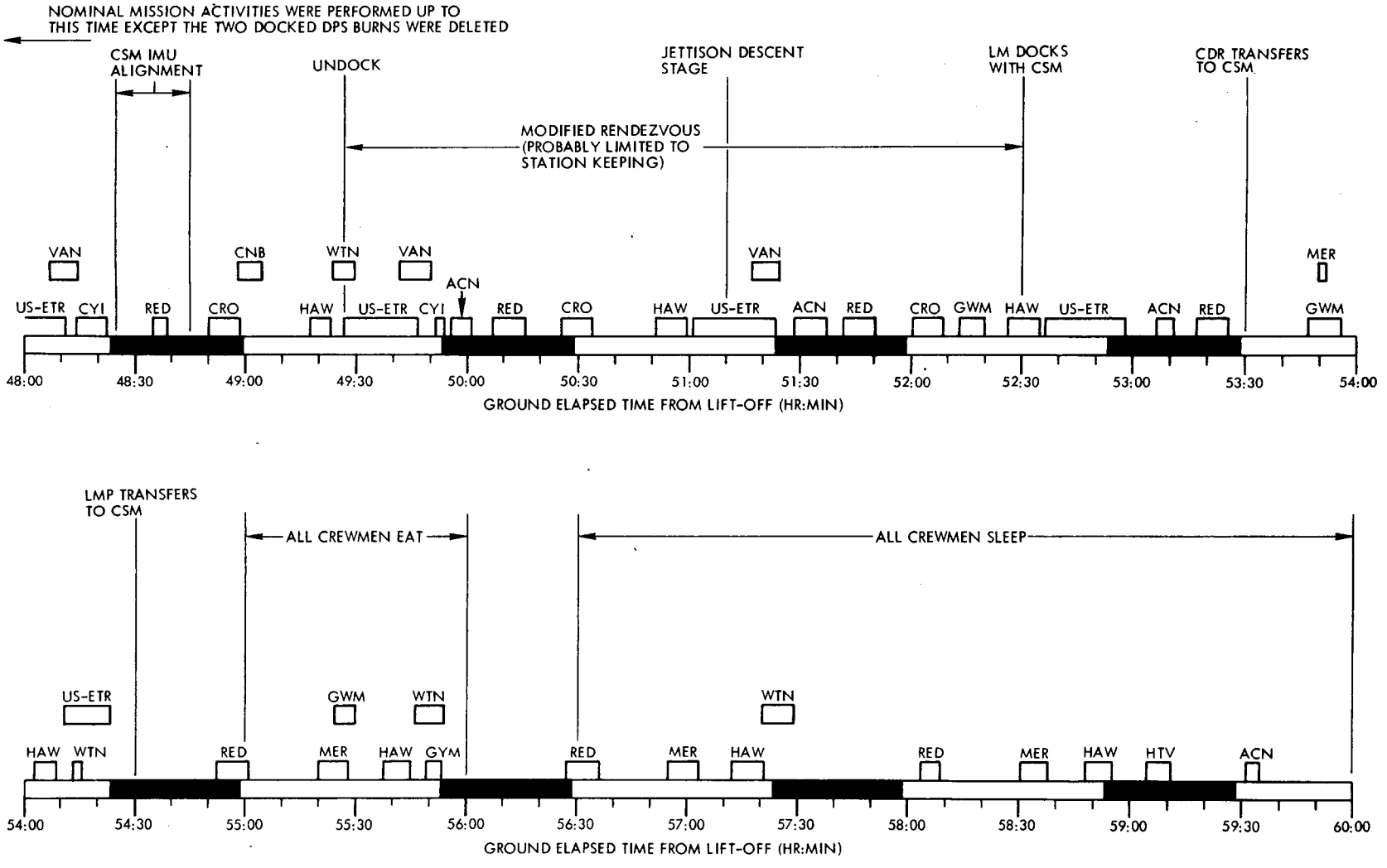


Figure 7-5. Alternate F-2a Mission Timeline

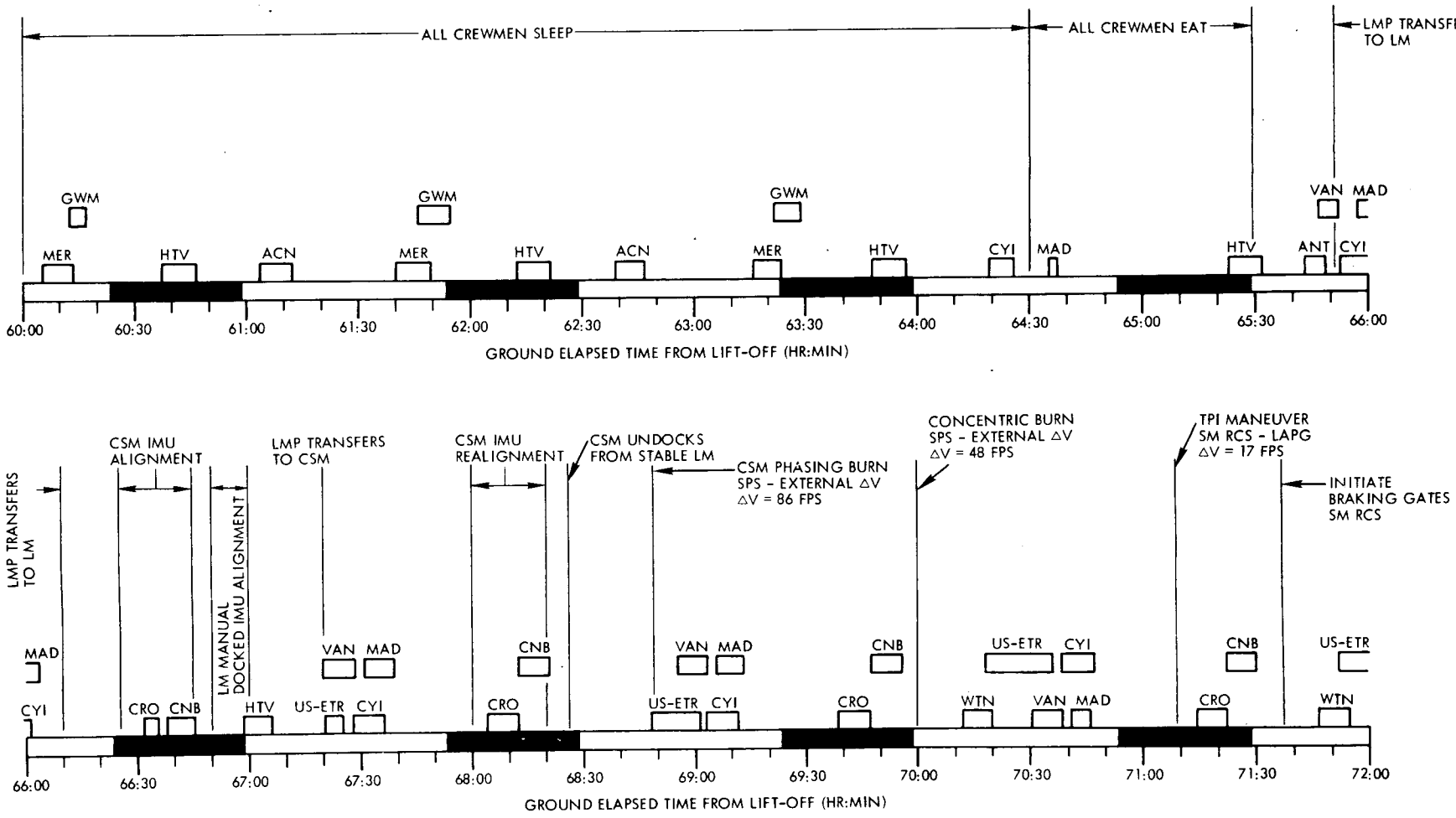


Figure 7-5. Alternate F-2a Mission Timeline (Continued)

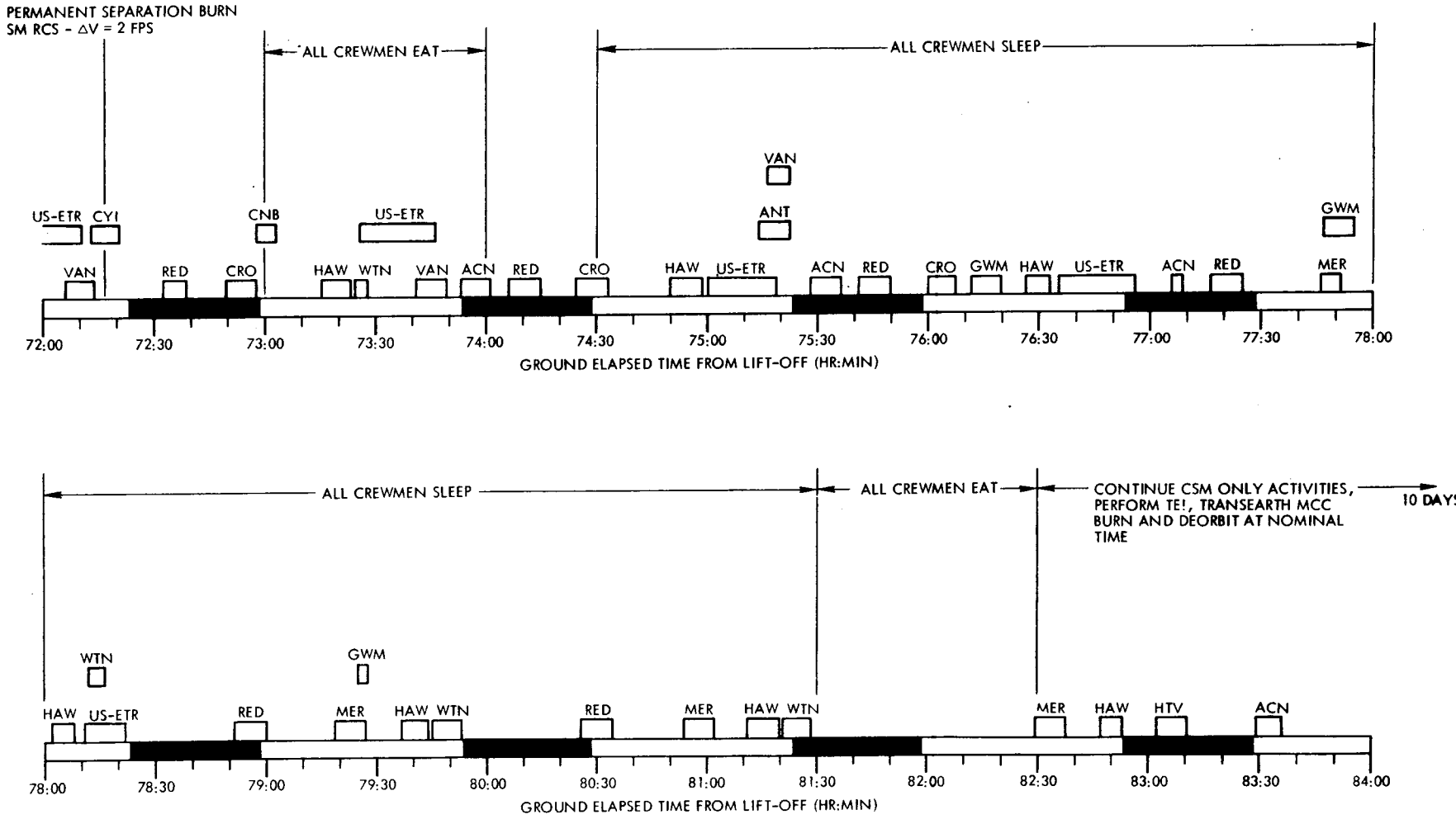


Figure 7-5. Alternate F-2a Mission Timeline (Concluded)

Alternate Mission G

7.7 ALTERNATE MISSION G

Alternate Mission G is utilized for four LM system failures. The major deviation from the nominal mission timeline is the substitution of a modified rendezvous in period 3. The selection of the modified rendezvous will be made in real time and will depend upon the failure precipitating the alternate mission and the remaining consumables. No mission timeline or spacecraft events summaries are included for this reason.

Alternate Mission G is invoked, if one of the following four failures occurs prior to the phasing maneuver in period 3.

a) LM PGNCS lost

b) Rendezvous radar failure

c) Descent stage electrical power failure

d) One ascent battery fails

The modified rendezvous plans for this mission will be presented in Section 8.

Modified rendezvous

8. GENERAL DESCRIPTION OF MODIFIED RENDEZVOUS

After finalization of the nominal E mission rendezvous, several modified rendezvous plans will be provided that can be incorporated in real time into one of the alternate missions. Systems and consumables status at the time of separation will dictate which plan to use.

A modified rendezvous is defined as any nonnominal rendezvous deliberately executed in real time instead of the nominal rendezvous plan. Nonnominal rendezvous plans precipitated by a failure after the initial phasing burn are considered as aborted rendezvous and will be documented separately.

DTO accomplishment

9. SUMMARY OF DETAILED TEST OBJECTIVES ACHIEVED BY THE ALTERNATE MISSION PLANS

Careful consideration was given to the detailed test objectives and their priorities in the design of each alternate mission. The extent to which each alternate mission timeline meets the set of detailed test objectives is summarized in Table 9-1. The alternate mission notation was described in Section 6.2 and the detailed test objectives are outlined in the Appendix. The entries in the table are as follows:

- O - detailed test objective satisfied
- ◉ - detailed test objectives partially satisfied
- ● - detailed test objective not satisfied
- ? - do not know the extent to which detailed test objective is satisfied

For convenience, the table presents the objectives in their assumed order of relative priority

Table 9-1. Alternate Mission - Detailed Test Objective Matrix

Priority		Detailed Test Objectives	A-1a	A-1b	B-1a	C-1a	D-1a	E-2a	E-3b	F-2a	G-3a
1	M20.46	Transposition/Docking/LM Ejection	●	◉	O	O	O	O	O	O	O
2	M20.44	Simulated LOI Maneuver	◉	◉	O	O	O	O	O	O	O
3	M20.48	LM Abort/Nominal Rendezvous	●	●	O	O	O	●	●	?	?
4	M20.45	Simulated TOI/Descent Burns	●	●	O	O	O	●	●	●	O
5	M16.9	LM S-Band Updata Link	●	●	O	O	O	O	O	O	O
6	M20.57	CSM/MSFN High Altitude Communication	●	O	●	?	●	O	O	O	O
7	M20.58	Star/Landmark Navigation	●	O	●	●	●	O	O	O	O
8	M20.59	Star/Earth Horizon Navigation	●	O	●	●	●	O	O	O	O
9	M2.9	GNCS/MTVC Takeover	●	●	O	O	O	O	O	O	O
10	S20.47	CSM-active Rendezvous	?	?	O	O	●	O	O	O	O
11	S20.51	Pre-TLI Checkout Timeline	●	O	O	O	O	O	O	O	O
12	S20.92	Simulated TLI Burn	●	O	●	◉	●	O	O	O	O
13	S20.60	Lunar Landing Sight Determination	O	O	O	O	O	O	O	O	O
14	S3.19	SPS Evaluation	O	O	O	O	O	O	O	O	O
15	S20.75	Passive Thermal Control Procedures	◉	O	O	O	O	O	O	O	O
16	S20.49	Simulated TEI Maneuver	O	O	O	O	●	O	O	O	O
17	S1.19	CSM and LM IMU Performance	◉	◉	O	O	O	O	O	O	O
18	S20.55	CSM Consumables-Lunar Timeline	O	O	O	O	O	O	O	O	O
19	S20.54	LM Consumables	●	●	O	O	O	O	O	O	O
20	S20.76	SPS/RCS Midcourse Correction Maneuvers	◉	◉	O	O	◉	O	O	O	O
21	S20.52	Single Crewman CSM Operations	◉	◉	O	O	O	O	O	O	O
22	S12.6	AGS Inflight Calibration and Performance	●	●	O	O	O	●	●	?	?
23	S20.39	Preprogrammed Launch Window	O	O	O	O	O	O	O	O	O

Code: O - Detailed Test Objective Satisfied

◉ - Detailed Test Objectives Partially Satisfied

● - Detailed Test Objective Not Satisfied

? - Do Not Know Extent to Which Detailed Test Objective Satisfied

Appendix

APPENDIX

SUMMARY OF TEST OBJECTIVES AND PRIORITIES

The detailed test objectives which were used in the preparation of the alternate missions are summarized briefly in this Appendix. These data are based on the material presented in Reference 2. The objectives are classified as mandatory (M), primary (P), or secondary (S). Personnel desiring detailed information on these objectives should consult the latest issue of the mission requirements document. The objectives are listed in the order of priority which was assumed for the alternate mission work described in this report.

Priority Number	Detailed Test Objectives
1	M20.46 Transposition/Docking/LM Ejection Perform CSM transposition, docking, and LM ejection after S-IVB simulated TLI burn.
2	M20.44 Simulated LOI Maneuver Perform a simulated LOI SPS guidance and navigation control system (GNCS) controlled burn in a fully loaded, docked configuration.
3	M20.48 LM Abort Rendezvous Perform an AGS controlled, LM-active rendezvous with the CSM. The purpose is to demonstrate the capability of performing an AGS controlled abort type rendezvous initiated by a simulated PGNCS failure.
4	M20.45 Simulated TOI/Descent Burns Perform simulated transfer orbit insertion, lunar descent, and DPS transearth abort burns with LM/CSM docked.

Priority Number	Detailed Test Objectives
5	M16.9 LM S-band Updata Link Demonstrate the capability of the S-band digital updata link to receive, process, and route digital messages to the LM guidance computer.
6	M20.57 CSM/MSFN High Altitude Communications Maintain CSM S-band communications at high altitude.
7	M20.58 Star/Landmark Navigation Perform star/earth landmark space navigation.
8	M20.59 Star/Earth Horizon Navigation Perform star/earth horizon space navigation.
9	M2.9 GNCS/MTVC Takeover Perform manual thrust vector control "takeover" of a GNCS initiated SPS burn. Since the manual thrust vector control (MTVC) is the first order backup to GNCS for the docked configuration, this objective must be satisfied prior to a lunar mission.
10	S20.47 CSM-active Rendezvous Perform a CSM-active rendezvous with the unmanned LM ascent stage using simulated CSM single crewman operation.
11	S20.51 Pre-TLI Checkout Timeline Perform a pre-TLI checkout and preparation and obtain data on crew task timeline. The purposes are to verify procedures and to obtain data on time required to perform pre-TLI sequence.
12	S20.92 Simulated TLI Burn Monitor the GNCS and displays during the simulated TLI burn.
13	S20.60 Lunar Landing Site Determination Perform earth landmark sighting in low-earth orbit to simulate lunar landing site determination. The purposes are to establish error uncertainties, evaluate procedures, and to determine service module (SM) RCS propellant consumption.

Priority Number	Detailed Test Objectives
14	S3.19 SPS Evaluation Perform a long duration SPS burn and monitor the primary and auxiliary gauging systems.
15	S20.75 Passive Thermal Control Procedures Obtain data on initial coning angles when in the spin mode as used during translunar flight.
16	S20.49 Simulated TEI Maneuver Perform a simulated transearth insertion SPS GNCS controlled burn.
17	S1.19 CSM and LM IMU Performance Obtain data to verify IMU performance in the flight environment. Similar IMU performance data have been obtained on Apollo Missions C and D; however, due to the significance of IMU performance to lunar mission success, additional inertial instrument performance data in the flight environment are desired to minimize guidance uncertainties during the powered flight phases.
18	S20.55 CSM Consumables-Lunar Timeline Obtain data to update current SM and CM consumables requirement estimates for conduct of a lunar mission.
19	S20.54 LM Consumables Obtain data to update existing LM and crew consumables requirement estimates for conduct of a lunar mission.
20	S20.76 SPS/RCS MCC Maneuvers Demonstrate system capability to perform MCC.
21	S20.52 Single Crewman CSM Operations Perform single crewman operations of the CSM from IVT to LM to final IVT to CSM.
22	S12.6 AGS Inflight Calibration and Performance Demonstrate an AGS calibration and obtain AGS performance data in the flight environment. The purposes are to determine AGS overall inertial sensor performance and to evaluate the AGS gyro and accelerometer inflight calibration functions.

Priority Number	Detailed Test Objectives
23	S20.39 Preprogrammed Launch Window Update GNCS for launch in preprogrammed window. The purpose is to evaluate the procedures required to launch in a preprogrammed window using the variable launch azimuth technique planned for lunar missions.

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